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UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey

of

Oceana County, Michigan

By

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United States Department of Agriculture, in Charge

and

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Bureau of Chemistry and Soils

In cooperation with the
Michigan Agricultural Experiment Station

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SOIL SURVEY OF OCEANA COUNTY, MICHIGAN

By C. H. WONSER, United States Department of Agriculture, in Charge, and J. O. VEATCH and L. R. JONES, Michigan Agricultural Experiment Station

INTRODUCTION

The income of the inhabitants of Oceana County, Mich., is derived chiefly from products of the soil. Fruit growing is an important source of cash income, and general farming, dairying, and poultry raising are practiced. On the whole, the farming is more or less of the self-sustaining type. The tourist trade brings in much revenue every summer, as the county is especially favored by having approximately 25 miles of shore line on Lake Michigan, along which there are many summer homes. There are also a number of large inland lakes and large tracts of wild land.

This county lies in that part of Michigan where Lake Michigan exerts a marked moderating effect on the temperature, preventing both abnormally low temperatures and sudden changes in temperature. The rainfall is well distributed throughout the growing season and is sufficiently abundant for most crops. Moderately warm summers and cold winters prevail.

Oceana County lies within the glaciated part of the United States, and the materials from which most of the soils have developed were laid down during the late Wisconsin period of glaciation. The soil materials vary considerably, from water-laid outwash sands to morainic sands, sandy clays, and heavy till clays. These different materials were laid down by the ice, and the soils are dependent on them for their present textures. The relief ranges from broad smooth plains to relatively hilly country.

This county lies within a belt between the Gray-Brown Podzolic soils that occur more generally in southern Michigan, northern Indiana, and Ohio, and the Podzol soils of northern Michigan. Most of the soils more closely resemble soils of the Podzol group than those of the group of Gray-Brown Podzolic soils.

About three-fourths of the land is well drained, and the remainder consists of imperfectly and poorly drained mineral and organic soils. More than one-half of the upland, or well-drained, part of the county was originally occupied by a forest in which white pine was dominant or characteristic, and the rest supported a mixed hardwood forest, in which sugar maple, beech, hemlock, ash, elm, and basswood were the most abundant species.

The well-drained soils are light colored and are lower in organic matter than the poorly drained soils. The cost of drainage, together with the greater susceptibility of injury from frosts to crops grown, has retarded the development of the low wet soils.

Fifty percent of the land consists of light-colored sand and loamy sand soils low in organic matter, moisture, and natural fertility, and

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it is, therefore, submarginal for production of the general farm crops and orchard fruits. More than 75 percent of the agricultural income is obtained from about one-fourth of the land.

The group of better general-purpose soils includes Isabella loam, Isabella sandy loam, Emmet sandy loam, and Emmet sandy loam, smooth phase. Any crop or tree fruit adapted to the climate can be grown on these soils, provided they have sufficient air drainage. Kent silt loam produces good yields of small grain, hay, and alfalfa, but it is not a good soil for fruit. Emmet loamy sand is an extensive soil, but much of it has been misused, with a consequent loss of fertility, partly through wind erosion. The sand soils, such as the Kalkaska, Roselawn, Plainfield, and Rubicon, in general, have not been successfully used for the production of the staple crops.

The more important imperfectly and poorly drained soils are members of the Bergland, Arenac, Ogemaw, Saugatuck, Newton, Munuscong, and Granby series. There are considerable areas of muck and peat soils, but they are not in general use for agriculture.

Dairying is carried on in connection with general farming to a considerable extent. The need of legumes and manure for the maintenance of soil productivity encourages some form of animal husbandry. Dairy cattle answer this purpose, and, in addition, furnish a regular cash income.

Large areas of well-drained soils with rolling relief, or with sufficient change in elevation to provide air drainage, together with the favorable temperature moderated by the influence of Lake Michigan, have made fruit growing important. Apples and cherries are the principal fruits grown, and considerable quantities of peaches, pears, and plums are produced. The production of peaches has been decreasing during the last 30 years, and the production of cherries and apples has been increasing.

COUNTY SURVEYED

Oceana County lies along the eastern shore of Lake Michigan about midway between the northern and southern extremities of the lower peninsula of Michigan (fig. 1). Hart, the county seat, is 76 miles northwest of Grand Rapids, 38 miles north of Muskegon, 230 miles from Detroit, and about the same distance from Chicago, by paved highways. The land area of the county totals 543 square miles, or 347,520 acres.

The surface features are chiefly the result of glaciation. The most conspicuous features are broad, smooth plains; broken and pitted plains; and rough, hilly, or gently rolling areas of ridges, knobs, basins, and valleys. The arrangement of these topographic forms is complicated and irregular. The hilly areas range in height from 50 to 200 feet above the plains. The rise in most places is gradual but in some places is rather abrupt.

Extending westward from Hesperia at the eastern county line to Ferry, thence south 4 miles, thence west to a point 1 mile north of Rothbury, and thence west and south to the southwestern corner of the county, is the boundary between a broad smooth plain on the south and a rolling hilly section on the north. One fingerlike extension of this plain extends northwestward from a point near Ferry

toward Hart. The plain to the south is practically featureless, but the section to the north of this boundary comprises a part of the lake border morainic system [1] which crosses Oceana County. The northwestern boundary of this morainic system enters the county slightly south of Stony Lake, extends northeast to Shelby, thence northwest to Mears, thence northeast to a point south of Hart, thence east 6 miles, and thence north through Crystal Valley to the northern county line. Lying east of the morainic section, practically all of Leavitt Township comprises another plain which lies at about the same elevation as the large plain crossing the southern side of the county, but it is separated from the larger plain by the area occupied by hills and valleys north of Hesperia. The highland north of Hesperia extends west and north and joins the main body of the lake border morainic system. Aside from the plain covering most of Leavitt Township, the large mass of morainic country through the central part of the county includes many small smooth plains lying at different elevations.

FIGURE 1.—Sketch map showing location of Oceana County, Mich.

Along the shore of Lake Michigan is a belt of sand dunes. This belt averages about one-half mile in width, and the maximum width is 1½ miles. The dunes, or hills, range in height from 50 to 200 feet above the lake and from 10 to 100 feet above the plains to the east. Extending north from Pentwater to the county line, just inland from the dunes, is a small area of smooth old lake plain, about 2 miles wide.

Between the belt of dunes and the lake plain on the west and the hilly upland area on the east is a broken and pitted plainlike area which, though higher than most of the plains, is lower than the dunes or the hilly area to the east. It is, as a whole, a plain, in that the tops of the knolls and ridges are on about the same level. In places, however, are high moraines, or areas of rounded hills, which extend inland from the lake shore. The general slope of this plain is north-

[1] LEVERETT, F., and TAYLOR, F. B. THE PLEISTOCENE OF INDIANA AND MICHIGAN, AND THE HISTORY OF THE GREAT LAKES. U. S. Geol. Survey Monog. 53, 529 pp., illus. 1915.

ward, and the northern side of it is considerably lower than the part surrounding Hart.

The changes that have taken place in the surface features since glacial times are in general slight and of small importance, as most of the streams are small and the land surface has been but slightly dissected. The main streams, in general, flow in old glacial drainage channels, and their branches extend back into the hilly upland sections. The drainage system is dendritic, although the main streams have only a few tributaries and these feeder streams, in turn, have few branches. In spite of the scarcity of streams, however, most of the upland is well drained, as the loose sandy structure of large areas renders internal drainage very effective.

Most of Leavitt Township consists of a poorly drained plain, with large areas of swamps to which streams have not been cut to sufficient depth to afford good drainage. Other swamp areas occur in the county, especially between the plain that stretches across the southern part and the section of hilly country, although none of them is so extensive as the one in Leavitt Township.

The county is drained by South Branch White, North Branch White, Pentwater, and South Branch Pere Marquette Rivers, and Stony and Flower Creeks, and their tributaries. These streams head in low wet muck or peat areas, springs at the foot of the moraines or hills, or in lakes. They have cut narrow valleys, most of which are not more than 20 or 30 feet deep, for distances ranging from 3 to 10 miles. Stony Creek directly west of Shelby flows in a narrow channel about 100 feet deep for a distance of about 4 miles, but the rest of its valley is similar to the valleys of the other streams.

The mean water level of Lake Michigan, measured in 1933, in the vicinity of Oceana County was 580.87 feet above sea level. The highest point in the county was 246 feet above the lake on the bluff in the northern part of section 28 of Claybanks Township.[2] Hart is 655 feet above sea level,[3] or 75 feet above Lake Michigan. The plain in the southern part of the county is 692 feet above sea level one-half mile south of Rothbury, and 685 feet above sea level 1½ miles farther west.[4] The area directly north and east of Crystal Valley ranges from 900 to 1,000 feet above sea level.[5] Most of the land lies at an elevation between 600 and 800 feet.

Two areas along the lake front, 5 and 3 miles long, respectively, are practically free of dunes, and the land level ranges from 50 to 240 feet above the level of the lake. The entire lake front is excellently suited for bathing beaches, as the beach is sandy, clean, and free of vegetation, and the lake bottom slopes very gradually to deep water. Summer-resort colonies have been built along the lake for a short distance south of Pentwater, north of Pentwater to the county line, at Little Point Sable, and at Stony Lake, and many summer homes are in the village of Pentwater. A State park is located along the Lake Michigan beach at Pentwater and another at Silver Lake, which is an inland lake of medium size 1½ miles from Lake Michigan. Summer cottages occupy the most desirable sites around this lake.

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[2] Elevations from lake survey charts.

[3] UNITED STATES DEPARTMENT OF AGRICULTURE, WEATHER BUREAU. CLIMATOLOGICAL DATA FOR THE UNITED STATES BY SECTIONS. MICHIGAN SECTION. v. 50, no. 13, pp. 49–56, illus. 1935.

[4] Elevations from United States Geological Survey topographic sheets.

[5] LEVERETT, F., and TAYLOR, F. B. See footnote 1, p. 3.

More than 60 lakes, ranging from small to medium sized, and having a total area of about 6 square miles, are in the county. Many of the lakes have marshy margins, making them less desirable for sites for summer cottages, but several of the larger lakes have excellent possibilities along their shores for summer resorts. The lakes and streams, as a whole, afford from fair to good fishing opportunities.

The rolling relief (in places contrasting with the smooth plains), the inland lakes, Lake Michigan, the dunes, and the forest cover combine to form many places of scenic beauty and interest.

Good drinking water is available, in most places, from shallow wells, ranging from 50 to 100 feet in depth, but many wells have been driven to a depth ranging from 200 to 500 feet. Artesian wells are fairly common, and springs that furnish clear clean water are numerous throughout the hilly sections.

The land was originally forested with several fairly distinct types of tree associations, the most important two being the coniferous forest, consisting of white pine with fewer red (Norway) pine and oak; and the deciduous or hardwood forest, with sugar maple, beech, and hemlock as the predominant trees. On the poorly drained and imperfectly drained mineral soils a mixed forest of elm, white ash, black ash, red maple, white pine, yellow birch, poplar, swamp white oak, and basswood are known to have grown. The more completely decomposed and better drained muck areas support a vegetal cover similar to the last named, and the other mucks support dense stands of white cedar, with fewer white pine, spruce, hemlock, elm, and ash trees. The peat areas support tamarack, poplar, white pine, spruce, and a few white cedars. The more acid peat bogs support blueberry, leatherleaf, ferns, mosses, and scattered black spruce. A very small part of the county originally supported a sedge and grass vegetation in marshes and small dry-land prairies. No virgin areas of white-pine forest remain, as the best trees were removed at an early date and the rest of the stand allowed to be burned over, but numerous small tracts of virgin or near-virgin stands of hardwood forest remain.

White men first settled the land now included in this county along the shore of Lake Michigan at the mouth of Whiskey Creek in April 1849, and within the next year 300 settlers were established on the shores of Stony and Pentwater Lakes and at the mouth of Whiskey Creek. The activities of the pioneers were confined to fishing and the making of shingles, and the settlers depended on the income from shingle bolts to buy supplies of staples from Chicago to supplement the proceeds derived from fishing and hunting. After 1850, sawmills were erected, and lumbering flourished until the supply of first-class white pine was exhausted. By 1855 a few farmers had settled in the county, and subsequent to this time agriculture developed rapidly.

Hartwick and Tuller's history of this county states that the county government was organized in 1855.[6] In 1860 the population numbered 1,816, and from this time on the increase was rapid. People from eastern United States and southern Michigan, and from Norway, Germany, and Poland were the chief settlers. According to the Federal census, the population of the county in 1880 was 11,699, and

[6] HARTWICK, L. M. and TULLER, W. H. OCEANA COUNTY PIONEERS AND BUSINESS MEN OF TODAY. HISTORY, BIOGRAPHY, AND STATISTICS OF HUMOROUS INCIDENTS. 432 pp., illus. Pentwater, Mich. 1890.

in 1910 it had reached its peak, 18,379. The western and central parts were at that time the most thickly settled, and Grant, Otto, Greenwood, Weare, Colfax, and the northern part of Crystal Townships were the most sparsely settled. In 1930 the population had decreased to 13,805, all classed as rural.

Hart, with a population of 1,690 in 1930, is the county seat and largest town; and Shelby, 7 miles south of Hart, had a population of 1,152 in that year. These two towns are the principal trading centers and are situated on a branch line of the Pere Marquette Railway extending from Muskegon to Hart. New Era, Rothbury, and Mears are small villages located along the same railway. Pentwater is a small lake port on Lake Michigan. Crystal Valley, Walkerville, Ferry, and Hesperia are trading points and post offices that are not on the railroad.

Muskegon, an important lake port, is 32 miles by paved road south of Shelby, and Ludington, another lake port, is 24 miles by paved road north of Hart. United States Highway No. 31, paved from Sault Ste. Marie to the southern State line, passes through Rothbury, New Era, Shelby, Hart, and Pentwater, and improved gravel roads connect all towns and important points. Most of the public roads follow section lines and reach all the settled sections. These roads are kept in fair condition and can be traversed by automobile most of the year, though snow in winter and mud in early spring often close many roads for short periods.

The county is fairly well supplied with telephone service and churches and is well supplied with public schools. The rural schools are the one-room type, but all the towns and villages have multiple-room schools. Some rural sections are supplied with electric power.

The business enterprises, other than farming, include a basket factory at Shelby, canning factories at New Era, Shelby, and Hart, a flour mill at Shelby, creameries where butter is made at Hart, Shelby, Hesperia, and in Claybanks Township, and a brass foundry and coat factory in Hart. Some commercial fishing is done at Pentwater.

CLIMATE

The climate is greatly influenced by Lake Michigan. Westerly winds prevail, therefore the lake moderates both summer and winter temperatures in that extremes of heat and cold or sudden changes from one to the other are rare. Thus growth, especially of fruit buds, is retarded in the spring until after much of the danger from frost is past. As the distance eastward from the lake increases, this moderating effect becomes less positive, and climatic conditions in the eastern half of the county probably are not so well adapted to fruit growing as in the western part. General farm crops, such as corn, potatoes, beans, and truck crops, many of which are grown on low soils, are frequently killed by early frosts in the eastern part as much as a month earlier in the fall than they are around Hart and Shelby and west of these towns.

The prevailing westerly breezes make the climate along the Lake Michigan beach ideal in summer, and the lake shore is extensively used for recreational resorts and summer homes.

The difference between the summer and winter mean temperatures is 43°. Normally the ground is frozen and covered with snow during most of the winter. The average snowfall is 61.4 inches.

The average length of the frost-free period in the western part of the county is 144 days, from May 16 to October 7, but killing frosts have occurred as late as June 23 and as early as September 2.

The rainfall is fairly evenly distributed throughout the growing season. Heavy downpours of rain causing severe erosion and beating of the soil are uncommon. The characteristics of much of the soil make it possible to cultivate or plow most of the land very soon after even heavy rains.

Table 1, compiled from the records of the United States Weather Bureau station at Hart, gives the normal monthly, seasonal, and annual temperature and precipitation.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Hart, Oceana County, Mich.*

[Elevation, 655 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1903)	Total amount for the wettest year (1912)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	27.7	65	−7	2.32	1.21	1.55	14.4
January	22.6	58	−26	2.46	1.91	5.30	18.4
February	22.3	57	−35	1.84	.31	1.99	14.0
Winter	24.2	65	−35	6.62	3.43	8.84	46.8
March	30.9	74	−16	1.94	1.05	1.24	7.6
April	44.6	86	10	2.53	2.05	.50	1.2
May	54.8	93	18	3.43	2.76	8.72	(1)
Spring	43.4	93	−16	7.90	5.86	10.46	8.8
June	65.1	101	30	2.52	1.05	2.10	0
July	70.0	101	32	2.52	2.78	10.90	0
August	67.2	98	32	2.37	1.97	1.87	0
Summer	67.4	101	30	7.41	5.80	14.87	0
September	60.7	96	20	3.25	.50	3.34	(1)
October	50.1	87	15	2.96	.75	1.49	.9
November	37.8	75	2	2.44	4.40	2.50	4.9
Fall	49.5	96	2	8.65	5.65	7.33	5.8
Year	46.2	101	−35	30.58	20.74	41.50	61.4

[1] Trace.

AGRICULTURE

The first settlers in Oceana County farmed small tracts of land to produce staple foods, mainly potatoes and corn, that were expensive or difficult to purchase. Their income was derived mainly from the forests. Early observers decided that the county had possibilities as a fruit-producing section, and peaches were planted as early as 1852. Livestock—hogs, sheep, and both beef and dairy cattle—and

livestock products began to be commercially important between 1860 and 1880. About 1860, fruit growing was taken up as a major pursuit, and by 1880 large numbers of apple, peach, plum, and cherry trees, together with grapes and small fruits, had been planted. During this time agriculture had developed from nonsupporting to a supporting and money-making industry, with fruits as the chief product for sale. According to figures given by local historians [7] for the year 1880, 1,856 acres of apple trees yielded 40,996 bushels, 211 acres of peaches yielded 10,876 bushels, and the total yield of cherries, currants, plums, and berries in that year was 2,030 bushels.

Table 2, compiled from the United States Bureau of the Census reports, gives important features of the agricultural development of the county between 1880 and 1935.

TABLE 2.—*Population; number, size, and value of farms; and ownership and tenancy of farms in Oceana County, Mich., in stated years*

Year	Population	Farms	Land in farms	Average size of farm	Average value of all farm property per farm	Assessed acre value of farm land	Farms operated by—		
							Owners	Tenants	Managers
		Number	*Percent*	*Acres*	*Dollars*	*Dollars*	*Percent*	*Percent*	*Percent*
1880	11,699	1,501	37.0	86.0	2,107	----------	94.5	5.5	----------
1890	15,698	2,037	43.2	74.0	2,458	----------	90.4	9.6	----------
1900	16,644	2,650	61.4	80.6	2,296	16.85	87.1	11.7	1.2
1910	18,379	2,806	70.1	86.8	4,259	27.71	87.5	11.3	1.2
1920	15,601	2,357	66.5	98.0	6,368	32.96	82.9	15.9	1.2
1930	13,805	2,012	58.0	100.1	6,584	[1] 53.53	86.6	12.4	1.0
1935	----------	2,089	61.9	103.0	----------	[1] 38.15	87.0	12.1	.9

[1] Including buildings.

Until 1900 the acreage devoted to general farm crops and fruits increased steadily, but since that time there have been several important changes in the trend of agricultural production. Acreages devoted to wheat, corn, and potatoes have declined, and the acreages sown to hay crops, rye, and beans have increased. In 1900 the peak in the number of peach trees was reached, but there has been a marked decline since that time. The number of cherry trees has increased greatly. The acreage planted to strawberries, raspberries, and currants also has increased since 1900. Since about 1880 the cash income of the county from fruits has exceeded that from any other group of farm crops.

According to the 1935 census report, 16,975 acres were planted to corn in 1934, about three-fourths of which was harvested for grain and the rest used for silage or fodder; 3,845 acres were in wheat; 6,046 acres in oats, most of which were threshed; 5,893 acres in rye; 22,706 in hay and sorghums for forage; and 4,503 acres in potatoes.

The principal truck crops are snap beans, cucumbers, asparagus, sweet corn, peas and celery.

Dairying has developed steadily since the early settlement of the county. The total income from dairy products in 1900 was $50,870,

[7] PAGE, H. R., & Co., publishers. HISTORY OF MANISTEE, MASON, AND OCEANA COUNTIES, MICHIGAN. pp. 79–154, illus. Chicago. 1882.

and in 1929 it was $530,381. The value of poultry and poultry products also increased, from $34,659 in 1900 to $369,227 in 1929.

Table 3 gives the value of all agricultural products in 1929.

TABLE 3.—*Value of all agricultural products, by classes, in Oceana County, Mich., in 1929*

Crop	Value	Livestock and livestock products	Value
Cereals	$318,971	Domestic animals	$1,326,137
Other grains and seeds	221,777	Butter, cream, and whole milk sold	530,381
Hay and forage	440,033	Butter churned	32,794
Vegetables, including potatoes	349,834	Wool shorn, unwashed	2,746
Fruits and nuts	892,490	Chickens	138,788
Farm vegetables for home use, excluding potatoes	37,485	Turkeys, ducks, and geese	13,086
All other field crops	2,068	Chicken eggs produced	217,353
Nursery, greenhouse, and hothouse products	24,165	Bees	6,880
Forest products	111,318	Honey produced	3,468
		Total	2,271,633
Total	2,398,141	Total agricultural products	4,669,774

On January 1, 1935, there were, on the farms of Oceana County, 3,807 horses and colts, 60 mules and colts, 16,814 head of cattle of all ages, 2,509 sheep and lambs, and 3,470 swine. Many chickens are raised, also a few turkeys, ducks, and geese.

During 1929 labor was hired by 45.9 percent of the farmers, or on 925 farms, the sum expended for this purpose totaling $285.641, or an average of $308.80 a farm reporting such expenditure. During the same year, 1,386 farms, or 68.8 percent of the total in the county, bought feed at a total cost of $249,540. Fertilizer was used that year on 797 farms, or 39.6 percent of the total number. The total expenditure for fertilizer during 1929 was $55,728.

Farmers using commercial fertilizers buy high-grade ready-mixed materials, for the most part, or "straight goods," such as sulphate of ammonia, muriate of potash, or superphosphate. Very little home mixing of fertilizers is done. The fertilizer is applied both by hand and by machinery. Fruits and potatoes receive most of the commercial fertilizer. The greater number of farmers, however, depend on crop and animal manures to maintain soil fertility. There are numerous deposits of high-grade marl in the county, and agricultural lime, in the form of marl, is extensively applied to the soil, both by general farmers and dairymen, to assist in the growth of all crops, especially legumes.

Labor on the general and dairy farms, and to a large extent on fruit farms, is supplied by resident whites and the farmer's family. The chief exception is that during cherry harvest a large number of transient workers from neighboring cities and towns are hired to pick the cherries. The cherry pickers are usually paid on a piece-rate basis which enables them to make fair day wages for unskilled labor. Wages of farm laborers vary greatly, depending on the time of year hired, arrangements for board, garden, rent, or other details.

In 1929 only 18 percent of the tenants paid cash rent, and the rest gave a part of the crop in rent. In case of share rent, the landlord usually bears one-half of the expenses for seed and fertilizer.

The farm buildings and farm equipment range from poor to good. In general, the investment in farm buildings and equipment is fairly high. The better facilities are in the better soil areas which are smaller in total area than are the poorer soils. As a rule, in areas where the soil is sandy and poor, the farm buildings are either poor or of medium value. The dwellings range from medium to large, and many are well built and well maintained. The average-sized barn is probably 30 by 40 feet, which provides space for storing hay and feed for livestock and for housing the livestock. Silos are rather common in the better farming sections.

The farm machinery, as a rule, includes two-horse implements for plowing, seeding, cultivation, and harvesting of crops. The number of tractors used is not large. Some farmers use only the minimum amount of labor-saving equipment and use hand labor for doing many seeding and harvesting operations that are done by machinery on larger farms in the southeastern part of the State. In 1929, according to the 1930 census, 163 farmers paid $6,030 to power companies for light and power, and 719 farmers spent $210,394 for machinery, automobiles, trucks, tractors, and implements.

According to the Federal census report for 1930, 76 percent of the farmers kept dairy cows and heifers for the production of milk. The average-sized herd on the dairy farms is eight animals, and the general and fruit farms usually have three or four dairy cows. The same census reported a total of 161 beef animals on 56 farms, but the number of beef animals has increased since that time. Both purebred and grade dairy cattle are kept, principally Jerseys, Guernseys, and Holstein-Friesians. Most of the milk produced is separated on the farms, where the skim milk is fed to hogs and chickens, and the cream is sold to creameries located within the county.

Most of the hay is consumed on the farms where produced, and most of the beef and pork produced are used in the homes. Beans are shipped through local elevators to consumption centers. A part of the fruit produced is canned within the county for shipment to other parts of the United States, and the rest is shipped by truck and rail to Grand Rapids, Benton Harbor, Detroit, Chicago, and other cities for consumption as fresh fruit.

In table 4 the soils of Oceana County are arranged in classes, in order to give a general idea of their use and potential value. Soils under class A are the best soils of the county, both for tree fruits and general crops, and Kent silt loam, which is not a good fruit soil, is also included in this class. Class C soils are good to fair soils for general farm crops but poor for tree fruits. Thus, class C includes second-class general-farming soils, but fourth-class fruit soils. Class B is a group of second-class tree-fruit soils, but third-class general-crop soils. The soils of class D are submarginal, both for general crops and fruits, as also are those of classes C and E for tree fruits.

TABLE 4.—*Grouping of soil types in Oceana County, Mich., according to agricultural capability and use*

Soil type	Approximate area	Location	Class and description	Present condition and use
	Acres			
Isabella loam, Isabella sandy loam, Emmet sandy loam, smooth phase; Emmet sandy loam, Kent silt loam, and Antrim sandy loam.	50,000	In medium-sized areas over entire county.	A. Most productive soils in county, adapted to largest number of crops. Sandy loams to silt loams; good moisture holders; do not require artificial drainage; not excessively stony; range from undulating and gently rolling to rolling in relief.	90 to 95 percent cleared and cropped. Best general-purpose soils in county. All except Kent silt loam excellent soils for tree fruits. Natural vegetation hardwood. Most valuable land in the county.
Oshtemo sandy loam, Montcalm sandy loam, Arenac fine sandy loam, Sparta loamy sand, Echo loamy sand, Emmet loamy sand, Kalkaska loamy sand, Arenac loamy sand, Coventry silt loam, Emmet loamy sand, smooth phase, Kalkaska loamy sand, broken phase, Ottawa loamy fine sand, and Ottawa fine sandy loam.	96,000	In medium- and large-sized areas over entire county.	B. From medium to low fertility; loamy sands to silt loams; do not require drainage; fair to poor moisture holders; most of them not excessively stony; from hilly to undulating in relief; require very careful soil management.	50 to 75 percent cleared and used for general crops and fruits. Large area made useless by erosion. Uncleared areas in hardwood forest and scrubby oak, aspen, and pine stumps.
Ogemaw sandy loam, Iosco sandy loam, Munuscong sandy loam, Newton sandy loam, Washtenaw sandy loam, Otto fine sandy loam, Granby fine sandy loam, Bergland loam, Maumee loam, Newton loamy sand, and Saugatuck sand.	40,000	In small to large areas over entire county.	C. From high to medium-low natural fertility; nearly all require some artificial drainage; good to poor moisture holders; need careful soil management; not excessively stony.	50 to 75 percent cleared and used for general crops and small fruits; not suited to tree fruits. Uncleared parts covered with brush and a mixed growth of conifers and hardwoods.
Roselawn loamy sand, Plainfield sand, Rubicon sand, Eastport sand, dune sand, Roselawn loamy sand, smooth phase, Rubicon sand, broken phase, Weare fine sand, Bridgman fine sand, and Wallace fine sand.	128,000	For the most part in large areas in all parts of the county.	D. Very low natural fertility; poor moisture holders; do not require drainage; need fertilizers, manures, and careful management for profitable crops. Generally submarginal soil.	10 to 20 percent utilized for a few subsistence crops. Remainder pastured pine-stump and grass land. Cut-over land grown up to scrub oak and underbrush.
Griffin silty clay loam, Griffin sandy loam, Kerston muck, Wallkill loam, Houghton muck, Carlisle muck, Greenwood peat, Rifle peat, and Warners loam.	34,000	Scattered in small to large areas over the county.	E. Alluvial, colluvial, and organic materials. All require drainage but are difficult to drain. They are especially subject to damage from frost.	10 percent or less cleared and utilized for special crops; rest pastured or used to supply wood, posts, and other forest products from its cover of white cedar, tamarack, pine, ash, elm, hemlock, and other swamp-tree species.

SOILS AND CROPS

As is common in glaciated sections, and especially in Michigan, the soils of Oceana County are extremely variable. They range from the high dry shifting sands of the dunes along the lake to heavy wet clay loams.

With the exception of a narrow strip along the Lake Michigan beach and small areas scattered about the interior, the county was originally forested. Two general types of forest cover grew—(1) the white pine forest and trees associated with it, chiefly red (Norway) pine and oaks; and (2) the hardwood forest, or an associa-

tion of sugar maple, beech, and hemlock. Soils on which the hardwoods grew, in general, are of higher natural fertility than soils on which the pines grew. A few pines were intermixed with the hardwoods in places, but, in general, the two types of forest—pine, or coniferous, and deciduous, or hardwood—predominated. The sands and loamy sands that supported a hardwood forest cover, although fairly high in fertility when cleared, soon become depleted under the type of cultivation that subjected them to wind and water erosion and losses of plant nutrients by a cropping system that returned no plant nutrients to the soil.

At present, the lands comprised of sandy loam, loam, and silt loam soils, together with poorly and imperfectly drained areas that have been artificially drained and areas of loamy sands that, because of their relief, are less subject to erosion or, because of better management, are not so depleted of fertility, are the source of the greater part of the agricultural income of the county.

Three main types of agriculture are practiced, but on many farms they are associated with each other. These are fruit growing, dairying, and general farming. According to the 1930 census, general crops from 67,622 acres and fruits from 14,087 acres were harvested in 1929.

Potatoes, beans, rye, and wheat are the principal general farm cash crops. On many farms some dairying is carried on, in addition to growing cash, subsistence, and fruit crops. Cucumbers and snap, or string, beans are grown by many farmers in small plots as extra cash crops.

Dairy farmers devote a large acreage to hay and feed crops but only a small acreage to a cash crop.

Fruit growing is well diversified. On many farms, apples, cherries, peaches, pears, plums, and small fruits are grown in the same or in adjoining orchards. Apples and cherries are the most important fruits and are becoming more important every year.

Climatic conditions, combined with type of soil, have been the principal factors in determining the type of agriculture pursued. The moderating influence on the climate by Lake Michigan and the rolling relief of large areas, which provides air drainage, tend to reduce the frost hazard in fruit production. Therefore, in many years, yields have been good when crop failures occurred in sections of the country less favored by location. Thus, it may be seen, natural factors, combined with favorable markets and transportation facilities, have influenced and directed the use of the land toward the production of fruit. The fact that large areas of very light textured soils are droughty for short-season shallow-rooted crops, has decreased the competition from other crops that fruit growing otherwise might have had. Some of the best soils of the county for general cash and subsistence crops, however, are also the best soils for tree fruits, and in order that fruit may be profitable, the orchard should be on good soil. Thus a more constant demand and price, combined with personal preference and experience, for potatoes, cereal crops, and dairy products have worked together to keep much good soil for growing fruit out of fruit production. Mistaken ideas as to the requirements of fruit trees and of the conditions to which

they can adapt themselves, have caused many acres of poor sand land to be set to fruit trees, with failure as a result.

The heaviest textured soils, or the silt loams, together with the poorly and imperfectly drained soils, are unsuitable for fruit production, on account of surface relief and air and water drainage, but they are very good general farming soils.

The soils of the county fall into three groups—(1) well-drained, (2) imperfectly drained, and (3) poorly drained soils. The well-drained soils are subdivided into two subgroups—well-drained silt loams, loams, and sandy loams, and well-drained loamy sands and sands. Based on total area, the soils of the latter subgroup are the most important, as they occupy about 56 percent of the land area, but, based on agricultural value, the soils of the first subgroup, which occupy 18 percent of the total area, are the most important. Thus it may be seen, the well-drained soils range from the poorest to the best soils of the county.

In the following pages, the discussion of the individual soils is taken up in detail; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 5.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in Oceana County, Mich.*

Type of soil	Acres	Per-cent	Type of soil	Acres	Per-cent
Kent silt loam	9,280	2.7	Dune sand	1,856	0.5
Isabella loam	4,224	1.2	Ogemaw sandy loam	3,584	1.0
Isabella sandy loam	3,392	1.0	Iosco sandy loam	512	.1
Emmet sandy loam	13,824	4.0	Arenac loamy sand	8,960	2.6
Emmet sandy loam, smooth phase	18,880	5.4	Arenac fine sandy loam	1,472	.4
Antrim sandy loam	1,152	.3	Otto fine sandy loam	704	.2
Ottawa fine sandy loam	128	.1	Saugatuck sand	9,344	2.7
Montcalm sandy loam	6,784	2.0	Eastport sand	768	.2
Coventry silt loam	2,752	.8	Bergland loam	1,792	.5
Oshtemo sandy loam	1,408	.4	Munuscong sandy loam	2,752	.8
Emmet loamy sand	33,024	9.5	Granby fine sandy loam	4,992	1.4
Emmet loamy sand, smooth phase	16,896	4.8	Newton loamy sand	11,136	3.2
Echo loamy sand	4,544	1.3	Newton sandy loam	640	.2
Kalkaska loamy sand	23,616	6.8	Maumee loam	2,624	.8
Kalkaska loamy sand, broken phase	3,264	.9	Griffin sandy loam	5,440	1.6
Sparta loamy sand	768	.2	Griffin silty clay loam	512	.1
Roselawn loamy sand	33,856	9.7	Washtenaw sandy loam	1,856	.5
Roselawn loamy sand, smooth phase	11,584	3.3	Wallkill loam	256	.1
Rubicon sand	24,128	6.9	Warners loam	128	.1
Rubicon sand, broken phase	6,400	1.8	Kerston muck	3,392	1.0
Plainfield sand	27,072	7.8	Carlisle muck	23,552	6.8
Ottawa loamy fine sand	2,368	.7	Houghton muck	1,472	.4
Ottawa loamy fine sand, rolling phase	128	.1	Rifle peat	2,688	.8
Wallace fine sand	832	.2	Greenwood peat	1,600	.5
Weare fine sand	960	.3	Burned muck over clay	128	.1
Bridgman fine sand	3,712	1.1	Burned muck over sand	384	.1
			Total	347,520	------

WELL-DRAINED SOILS

WELL-DRAINED SILT LOAMS, LOAMS, AND SANDY LOAMS

Kent silt loam.—Kent silt loam is developed under a forest cover of hardwoods. More than 90 percent of it has been cleared and is utilized in agriculture. It occurs in scattered large areas, especially in Claybanks, Benona, Hart, and Weare Townships, and in smaller areas elsewhere. Topographically, most areas of Kent silt loam are

on plains broken in places where the natural drainageways are gully-like with steeply sloping sides ranging from 10 to 30 feet in height. Both surface and internal drainage range from good to slow. The natural fertility of this soil is medium high, and, although the soil is excellent for alfalfa, and from fair to good for wheat, corn, oats, and beans, it does not produce such good yields of potatoes as the lighter textured soils, and it is not well suited to peach and cherry trees.

The surface soil is grayish-brown or dark grayish-brown fine-granular heavy silt loam. The heavy texture necessitates very careful management, especially of tillage operations after rains. It is somewhat hard to plow and will bake after rains. There are but few stones and boulders to interfere with cultivation and plowing. The subsoil consists of red heavy clay or silty clay, which is plastic and sticky when wet and breaks in small blocks when dry. The material in this layer, as well as that in the layer above, ranges from strongly acid to medium acid. In most places, at a depth ranging from about 20 to 36 inches, the clay becomes more friable, is less sticky and plastic when wet, is of a lighter shade, and is alkaline in reaction. Because the layer rich in lime is so near the surface, alfalfa is successfully grown in many places, without applications of lime or marl.

Crop yields depend on the practice of the individual farmer and on seasonal conditions. Owing to the impracticability of working this soil when wet, plantings of crops are frequently delayed. Barnyard and green manures are especially needed to loosen the soil structure, thereby making the land easier to work, more retentive of moisture, and more productive. Acre yields that can be reasonably expected under normal seasonal conditions and fair to good management are as follows: Wheat, 15 to 30 bushels; hay, 1 to 3 tons; oats, 25 to 45 bushels; corn, 20 to 40 bushels; and beans, 10 to 20 bushels. Apples and pears are grown in small home orchards.

Small areas of other soils are included with Kent silt loam as mapped. Common inclusions are some small wet spots and sandy spots. Many of the sandy spots have a reddish-brown hardpan. These are Ogemaw sandy loam, and the wet poorly drained areas are Bergland loam.

Isabella loam.—Isabella loam originally supported a hardwood vegetation. It occurs in widely separated places, but principally in Claybanks, Weare, and Crystal Townships. The relief is bolder or more rolling than that of Kent silt loam, but most of the slopes are not steep enough seriously to interfere with cultivation. This is probably the most productive soil for general farm crops in the county, and it is also a very good soil for tree fruits.

The surface layer, or plow soil, of Isabella loam, like that of Kent silt loam, is dark grayish brown, but it is lighter textured and more friable than the Kent soil. The underlying material is a 5- to 10-inch layer of grayish-brown sandy loam or loam. This, in turn, is underlain by heavy reddish-brown sandy clay. The soil is strongly acid to a depth ranging from 30 to 40 inches where the clay becomes more sandy or friable, lighter in color, and alkaline, or sweet, in reaction.

Good stands of alfalfa, without applications of lime or marl, are more difficult to obtain on Isabella loam than on Kent silt loam. Yields of potatoes are good, ranging from 100 to 250 bushels an acre. Yields of other crops are as good as, and in most places better than, those obtained on Kent silt loam. Tree fruits grown on this soil do very well. Probably more apples are grown on it than peaches or cherries.

Areas mapped as Isabella loam vary considerably in texture, as some small spots are much more sandy. Very small areas of Ogemaw, Arenac, and Isabella sandy loams are included in bodies of Isabella loam as mapped. An area mapped as Isabella loam 1½ miles southwest of Crystal Valley differs from the typical soil, in that the red clay subsoil is nearer the surface and the soil more closely resembles Kent silt loam, but it is slightly lighter in texture than the Kent soil and is more productive.

Isabella sandy loam.—Isabella sandy loam, although of comparatively small total acreage, is a fertile and agriculturally important soil. It is closely associated with Isabella loam. Some of the larger areas are in western Claybanks, western Golden, and eastern Greenwood Townships.

Isabella sandy loam differs from Isabella loam, in that the topsoil, or plow soil, is dark-gray friable sandy loam, and the dark reddish-brown sandy clay layer in most places is from 5 to 10 inches farther below the surface than in Isabella loam. The sandy loam is strongly acid to a depth ranging from 12 to 20 inches greater than in Isabella loam. The relief is very similar to that of Isabella loam.

The cultural requirements and crop adaptations of Isabella sandy loam are very similar to those of Isabella loam, and yields obtained on the two soils are about the same. The sandy loam, however, is more susceptible to soil washing, and many fields and orchards have decreased in productivity from this cause. The sandy loam is used extensively in the western part of the county for growing fruit. It is as good a soil for growing apples, peaches, and cherries as any soil in the county. The annual growth made by fruit trees on this soil is very good, and excellent yields of high-quality fruit are obtained from orchards that are given reasonable care.

Emmet sandy loam.—Emmet sandy loam is a soil of the hardwood hill lands. The larger areas occur in Shelby, Elbridge, and Hart Townships. The relief ranges from gently rolling to hilly. In places sufficient stones and boulders are present to interfere with cultivation or to make removal of them a problem. Many slopes are too steep for the use of labor-saving machinery. The soil is subject to erosion by water where the slopes are left unprotected by a plant cover.

The surface soil of Emmet sandy loam to plow depth is dark-gray friable sandy loam, which is fairly high in organic matter and very fertile when first cleared. Below the plow soil, in most places, is a 2- to 5-inch layer of ash-gray sand. In some places a part or all of this layer has been mixed with the upper layer of soil in plowing. At a depth ranging from 8 to 12 inches is a layer of dark yellowish-brown or umber-brown sandy loam or loamy sand, extending to a depth ranging from 12 to 20 inches. Beneath the dark-brown layer is a layer of pale yellowish- or grayish-brown sandy

loam that is acid in reaction, whereas the topmost 18 or 20 inches of the soil material is strongly acid. At a depth ranging from 30 to 60 inches is a 4- to 12-inch layer of brownish-red sandy clay which ranges from neutral to alkaline in reaction and is very effective in preventing the downward movement of water, thus holding moisture so that the upper part of the soil does not become so dry as do the sandier soils. Below the clayey layer the material contains an abundance of lime and ranges from sand and gravel to a mixture of sand, clay, and silt.

This soil includes numerous variations from typical. Many areas of deep sand soil occur within its boundaries, as well as spots of Kent silt loam, Isabella loam, Isabella sandy loam, and other soils that are too small in area to map separately.

All the general farm crops grown on Isabella loam and Isabella sandy loam are grown profitably on this soil, in addition to rye. This is a good soil for growing potatoes, and acre yields of good-quality potatoes range from 100 to 250 bushels. Rye yields from 10 to 20 bushels an acre, and in fields in which the fertility has been maintained, yields of other crops may be expected to be about the same or slightly less on this soil than on Kent silt loam. Although this soil ranges from medium to strongly acid to a depth ranging from 2 to 4 feet, in some places, particularly where the soil is uncommonly gravelly or the clayey layer is near the surface, alfalfa can be grown successfully without applications of lime or marl. This is an excellent soil for tree fruits, and a large acreage is devoted to the production of peaches, apples, and cherries.

Emmet sandy loam, smooth phase.—The smooth phase of Emmet sandy loam includes areas of Emmet sandy loam which occur on nearly level uplands. Soil of the smooth phase is in general more uniform in texture and in depth to the sandy clay layer. It occurs in close association with Emmet sandy loam. Some of the more extensive areas lie east, west, and north of Hart.

The relief is the factor used in separating soil of this phase from the typical soil. Areas of Emmet sandy loam are sufficiently hilly to prevent or interfere with the use of tractors and other labor-saving machinery, but the smooth phase includes those areas in which the relief does not offer any serious obstacle to cultivating or harvesting operations with machinery. As soil of this phase is less subject to erosion, fields have not deteriorated so rapidly since clearing as have many on the more hilly typical soil.

This is one of the principal soils in the county for growing fruit, as well as general and special crops. All the crops commonly grown can be produced very successfully if good soil management is practiced, and yields average as high as those on the Isabella soils.

Antrim sandy loam.—The total extent of Antrim sandy loam is small. The more extensive areas are north of Shelby and northeast of Crystal Valley, and smaller areas are scattered in different sections of the county. This soil occupies benches at the bases of steep slopes or on valley floors. The relief is undulating or gently sloping. Very few areas contain sufficient stones or boulders to interfere seriously with cultivation, and practically all the land is cleared and under cultivation.

The 8- to 10-inch plow soil, or topsoil, is dark-gray or very dark gray mellow friable gravelly sandy loam. In some places cobblestones with a maximum diameter of 3 inches are embedded in the soil material, and in other places neither gravel nor cobbles are present. This layer is underlain by a 1- to 3-inch layer of ash-gray sand, and beneath this is a layer of reddish-brown sand, gravel, and some clay, ranging from 6 to 12 inches in thickness. This layer, in turn, grades into yellow sand in some places and in others into a grayish-yellow gravel and sand mixture.

Included with Antrim sandy loam as mapped is a small area of similar soil on the plain on which Hesperia is located. This soil probably developed under a grass cover, as indicated by the very deep dark topsoil, and in comparatively recent times a hardwood forest grew up. The 6- to 10-inch plow soil here is very dark gray fine sandy loam. It is underlain, to a depth of about 2 feet, by grayish-brown sandy material. Beneath this is a layer of reddish-brown sandy and gravelly clay ranging from 6 to 12 inches in thickness, and below this is stratified calcareous sand and gravel.

Antrim sandy loam in some places is imperfectly drained, but practically all of this soil in Oceana County is sufficiently well drained for the production of tree fruits, and some excellent orchards are growing on it. In crop adaptation and yields this soil compares favorably with the smooth phase of Emmet sandy loam. Yields probably average slightly lower on Antrim sandy loam, even under good soil management. The Antrim soil is acid to a depth of 3 feet or more, except in places where the substratum is gravelly, as the gravel is alkaline.

Ottawa fine sandy loam.—Ottawa fine sandy loam is of very small extent. Only three small bodies, one in section 35 of Benona Township and the other two in sections 3 and 4 of Weare Township, are mapped.

This soil is characterized by a distinctly loamy dark grayish-brown topsoil, a grayish-yellow loamy fine sand subsoil which extends to a depth of 3 or 4 feet, and a heavy brownish-yellow clay substratum. The sandy part of the soil is acid, but the underlying clay is alkaline.

The yields of corn, oats, beans, rye, potatoes, and hay obtained are about the average for the county.

Montcalm sandy loam.—Montcalm sandy loam was originally forested with a hardwood type of forest consisting principally of maple, beech, and hemlock, but white pine was locally abundant and even dominant on the sandier areas. The relief ranges from undulating and gently rolling to hilly, though very little of the land is sufficiently steep to interfere seriously with cultivation. This soil occurs chiefly in Grant, Otto, Greenwood, and Newfield Townships.

Montcalm sandy loam is in many respects similar to Emmet sandy loam. It differs from that soil in that it is more acid in the parent drift, contains less organic matter, and in most places is lighter textured.

In a plowed field the topmost 6- or 8-inch layer consists of gray or yellowish-gray sandy loam. In places where erosion has taken place, the topsoil may be dark-red sandy clay, and elsewhere it may

be gray sand with little or no finer material mixed with it. Below the topsoil and continuing to a depth of about 24 inches, the material is pale brownish-yellow loamy fine sand. This is underlain by yellowish-brown very light sandy clay which is somewhat cemented when dry but slightly sticky when wet. This layer ranges from 2 inches to 2 feet in thickness and in some places is made up of alternate layers of sand and sandy clay. In most places beneath the clayey layer the material is acid yellow sand, but in some places it consists of calcareous silt, fine sand, clay, or mixtures of all three. In a few places calcareous material occurs within 36 inches of the surface. The topsoil nearly everywhere is strongly acid.

About 50 percent of the land is cleared and farmed. Beans, rye, corn, oats, hay, and potatoes are the principal crops. Fair yields are obtained on farms where a good soil-improvement program is carried out. This soil especially needs lime or marl and large applications of manures.

An area mapped as Montcalm sandy loam in section 11 of Grant Township has a smooth silty feel rather than a sandy gritty feel, indicating that it is higher in silt than the typical soil. Its use and value are about the same as those of typical Montcalm sandy loam. Montcalm sandy loam is closely associated with Roselawn sand, and areas of Roselawn sand that are too small to map separately occur within the boundaries of Montcalm sandy loam and, vice versa, small bodies of Montcalm sandy loam are within the boundaries of Roselawn sand areas.

Coventry silt loam.—Coventry silt loam occurs only in central and western Colfax Township. It was forested originally with a mixture of white pine and hardwoods. It is closely associated with Roselawn sand and also resembles the Montcalm soil, but it is peculiar in that the surface soil is silty and heavier textured, and the subsoil and substratum are fairly uniformly sand or are much sandier than the material in the upper 3 or 4 feet. The relief ranges from undulating to gently rolling, but most of the slopes are not sufficiently steep to interfere seriously with cultivation.

The plow soil, or topsoil, is gray or light yellowish-gray smooth silt loam containing very few stones or boulders, and in most places it is low in organic matter. Below the plow soil, and continuing to a depth ranging from 15 to 20 inches, is brownish-yellow silty loam. This is underlain by a layer of a reddish-brown light sandy clay and clay-sand mixture about 15 inches thick. Below the clayey layer is loose pale reddish-brown and grayish-brown medium sand. The material in all layers is very strongly acid to a depth of 5 feet or more, and tests indicate that the soil is low or medium in all essential plant nutrients; but, as it holds moisture fairly well, from fair to medium yields of beans, rye, oats, corn, and potatoes are obtained.

This soil needs applications of lime or marl, together with barnyard or green manures, in order to increase the organic-matter content and available plant nutrients.

Oshtemo sandy loam.—Oshtemo sandy loam occurs in a few scattered small bodies throughout the southern tier of townships and in a few areas in other sections. It occupies nearly flat or undulating plains, closely associated with pineland, and the original forest growth probably was pine.

The topsoil is grayish-brown loamy sand, and the material below this, extending to a depth ranging from 20 to 30 inches, is yellow loamy sand. This is underlain by a reddish-brown sandy clay layer 6 or 8 inches thick. The deeper substratum material consists of stratified coarse sand and gravel, which generally carries considerable lime.

In the eastern part of the county this soil is used chiefly as a source of sand and gravel for road and cement work, and the areas in the western part are used for general crops and tree fruits. Corn, oats, and rye are the most important crops. Yields are in general lower than those obtained on the other soils of this group, as this soil is deficient in essential plant nutrients, as well as being droughty.

Included with Oshtemo sandy loam as mapped are small bodies of similar soil, west of Hesperia and in Shelby and Elbridge Townships, in which the plow soil is grayish-brown gravelly sandy loam fairly high in organic matter. At a depth of about 18 inches is a 5- or 10-inch layer of reddish-brown gravelly sandy clay. Above and including the sandy clay layer the soil is strongly acid, but below it the material is alkaline gray sand and gravel. Most of these included areas have gravel pits located on them, and the sand and gravel substratum is utilized for road surfacing and cement work. From fair to good crop yields are obtained from general crops on the small areas cultivated.

WELL-DRAINED LOAMY SANDS AND SANDS

This subgroup of the well-drained soils includes more than 50 percent of the total area of the county. As regards ordinary farming these lands are largely marginal or submarginal, either naturally or through use or misuse. Lumbering operations and later burning over have left approximately 100,000 acres of land, originally largely in white pine forest, which are of little value to agriculture and on which the pine forest has not been restored. Poor agricultural management has definitely reduced the value of many thousands of acres of hardwood lands.

The soils of this subgroup are, as a whole, excessively drained or are poor moisture-holding soils. Crops grown on them suffer from lack of moisture in seasons of low rainfall, as well as from lack of available plant nutrients.

Emmet loamy sand.—Emmet loamy sand is one of the most extensive soils of the county. It occurs throughout nearly all sections, but mainly around Shelby. The original vegetation was a hardwood forest consisting principally of sugar maple, beech, hemlock, basswood, ash, and elm trees. The relief ranges from gently rolling to hilly. Most of this soil has a few stones and boulders scattered on and through the soil, but they are not sufficiently numerous to present a very serious problem.

In a field that has been recently cleared or one that has been well cared for, the plow soil is very dark gray loamy sand high in organic matter. In fields which have been clean cultivated for a long time, without the addition of organic matter, the surface soil is yellow or very light gray sand. All gradations between these two extremes occur. Beneath the topsoil of the well-cared-for or recently cleared land, the soil consists of a layer of coffee-brown sand or loamy sand,

ranging from 2 to 10 inches in thickness, and in many places it lies near enough to the surface that it has been mixed with the topsoil during plowing or lumbering operations. The material below this is grayish-yellow sand. In most places this soil ranges from strongly to medium acid, but the substratum is limy at a depth ranging from 5 to 8 feet.

When first cleared, this soil produced good yields of rye, beans, potatoes, corn, and all tree fruits, in seasons of good rainfall. Careless management, however, has reduced the fertility of the land and in many places, led to wind or water erosion, so that at present thousands of acres are practically useless for the production of general farm crops and fruits. A long and expensive program of restoration will be necessary before this soil will be suitable for permanent agriculture.

Probably 20 percent of this land, mainly on the rougher slopes, is still forested, but the rest has been cleared and at some time has been under cultivation. Much of the cleared land either has been abandoned or is used as pasture. Where the original fertility has not been completely depleted, cherry trees make a fair annual growth and produce medium-sized crops of cherries, provided the soil and trees receive good care. Under present conditions, grain, hay, and potatoes make poor or only fair yields. In the more completely destroyed fields, rye is practically the only farm crop that will mature without special treatment. From good to fair responses are obtained from the use of lime or marl, manures, and commercial fertilizers.

Emmet loamy sand, smooth phase.—The smooth phase of Emmet loamy sand is closely associated with typical Emmet loamy sand. It occurs at the bases of steep slopes in a benchlike position and within the hilly areas of Emmet loamy sand where the relief is not sufficiently steep to interfere with the use of labor-saving farm machinery. The favored position of this smoother land has protected it from wind and water erosion and at times has enriched it at the expense of higher lying land, from which the topsoil materials have been washed.

A large proportion of this land is under cultivation, either to fruits or general crops. From fair to good orchards occupy much of the land, and they give profitable returns if the soil and trees are well cared for. From medium to good yields of potatoes, rye, beans, corn, and hay are obtained, when maintenance of fertility and soil-building programs are practiced. Applications of lime or marl, manures, and commercial fertilizers are needed, and they give good returns in increased quality and yields of crops. A deficiency of moisture is often a limiting factor in crop yields.

Echo loamy sand.—Echo loamy sand occurs in close association with the Emmet soils. It occupies the dry runs, or valleys, between ridges or hills in the Emmet and Roselawn soil areas. These runs, or valleys, receive wash and drift from the slopes and hills, that enrich the soils in them in plant nutrients and moisture at the expense of the soils on the slopes. The moisture is supplied both from surface run-off and underground seepage. Owing to the more favorable conditions, all crops and fruits on Echo loamy sand grow better and yield more than on the surrounding uplands. Many of the Echo loamy sand areas lack air drainage and are subject to early

and late frosts. Therefore, they are not so favorable for the production of fruit. Crop adaptations and fertility requirements are about the same as on the smooth phase of Emmet loamy sand, and yields are usually slightly higher.

Kalkaska loamy sand.—Kalkaska loamy sand occurs chiefly in the northwestern quarter of the county. It occupies broad smooth somewhat flat or undulating plains that originally supported dense stands of hardwood forest similar to that covering Emmet loamy sand. Probably less than 10 percent of the area of Kalkaska loamy sand is still covered with good stands of hardwood timber.

The plow soil of a fairly recently cleared and cultivated field consists of gray or dark-gray loamy sand rather high in organic matter. It is underlain by a thin layer of ash-gray sand. At a depth of about 10 inches is a layer of deep-brown or umber-brown loamy sand which ranges from 4 to 12 inches in thickness, and below this the material is gray sand to a depth of several feet. This soil is strongly acid to a depth ranging from 4 to 6 feet or more.

In places where large areas of this soil on a broad plain are cleared, the topsoil has a strong tendency to blow, and from large bodies, principally in Weare Township, the topsoil has been blown away. Under these conditions or in other places where the land has been cropped for several years under indifferent management, the soil is droughty and lacking in essential plant nutrients.

Where it has been reasonably well cared for, Kalkaska loamy sand produces fair crops of rye, corn, beans, oats, and potatoes. One large field is planted to asparagus which returns fair yields. The wind-eroded areas, for the most part, are pastured or allowed to lie idle. Some tree fruits are grown and give medium yields.

A few fields of this soil were observed that bear witness that fair yields of general crops can be obtained where the soil is newly cleared or built up by manures, legumes, and careful management.

Kalkaska loamy sand, broken phase.—The broken phase of Kalkaska loamy sand occurs chiefly on the broken plains west of Shelby and in the northwestern corner of the county. The difference between this soil and typical Kalkaska loamy sand is in relief. Soil of the broken phase occurs in rough, broken, and pitted plains, where a large part of the land occupies slopes. All the higher areas of such plains seem to be on about the same level. Soil of this phase has been subjected to wind and water erosion. Therefore, much of it has been reduced in value in a manner similar to that affecting Emmet loamy sand.

This soil is largely marginal and submarginal for cultivated crops, although small patches are planted to corn, rye, hay, beans, potatoes, and cherries.

Sparta loamy sand.—Sparta loamy sand is very inextensive, and practically all of it is in Greenwood Township. It occupies small areas on the smooth plain that forms much of Grant, Otto, and Greenwood Townships and extends into Muskegon County along White River, locally called the "White River skims." This plain is composed chiefly of dry sand covered with scrub oaks mixed with small jack pines and white pines. The oaks predominate, and the pines grow only in scattered areas. The small oddly shaped bodies of Sparta loamy sand support a grass vegetation, together with a few scattered oak trees.

The 12-inch topsoil is very dark brownish-gray or nearly black loamy sand high in organic matter. If the organic matter were removed, the soil probably would be medium sand in texture. Between depths of 12 and 24 inches the material is brown acid medium sand, and below a depth of 24 inches gray medium sand extends downward for several feet, probably to a depth of more than 10 feet.

Little or none of this soil is cultivated, but it undoubtedly would produce from small to fair yields of corn, beans, rye, oats, and possibly potatoes. It does not occur in large enough areas to become important in the agriculture of the county. Lack of moisture would probably be a limiting factor in crop yields, except in seasons of abnormally high rainfall.

Roselawn loamy sand.—Roselawn loamy sand is an extensive soil. Originally it supported valuable stands of white and red (Norway) pine, intermixed with a few oaks. The land has been entirely cut over, as well as burned over, since the coming of white settlers. Large areas are now covered by grass, pine stumps, and sweetfern; others support a cover of scrubby oak and aspen; and still others are covered with grasses. Most of the pine stumps still remain. Probably less than 5 percent of the land is under cultivation. The land is gently rolling, but most of the slopes are not especially steep or long.

This soil occurs in three large bodies, one east of New Era in Shelby, Grant, and Otto Townships; one in Newfield Township; and the third in the northern parts of Colfax and Crystal Townships. A few stones and boulders are scattered over the land.

The topsoil of Roselawn loamy sand is gray or grayish-brown sand, low in organic matter, underlain by yellowish-brown sand that has a slightly loamy feel. At a depth of 12 inches this material grades into grayish-yellow sand. This soil ranges from medium to strongly acid to a depth of 5 feet or more.

Small yields of beans, corn, and rye are obtained from the small cultivated areas. In some places, only small plots of corn and vegetables are grown for subsistence. As a rule, the men farming this soil have areas of Echo loamy sand, or areas of some imperfectly or poorly drained soil, on which they produce the greater part of their subsistence crops. In its present condition and with its present grass cover, Roselawn loamy sand has little value for pasture, as the grasses dry during the summer. A small amount of pasture, however, is obtainable during the spring and fall. Under present economic conditions, Roselawn loamy sand does not support a profitable agriculture.

Roselawn loamy sand, smooth phase.—The smooth phase of Roselawn loamy sand is separated from typical Roselawn loamy sand on account of its smoother and more nearly level relief. Much of the smoother land is surrounded by the more rolling areas of the typical soil. The soil is a deep sand, but the land has a little more value for agriculture and forestry than the sloping or hilly land.

Rubicon sand.—Rubicon sand also is an extensive soil. The larger areas are around Rothbury in Grant and Otto Townships, and around Mears in Golden and Benona Townships. It constitutes the dominant "pine-plain land" of the county. The relief is undulating or nearly level.

This soil is very similar to Roselawn loamy sand, but it contains practically no stones or boulders, and it is less loamy and more uniform in texture than the Roselawn soil. Rubicon sand consists chiefly of medium sand, with only a comparatively small content of fine sand and coarse sand. The surface soil in places is a little higher in organic matter than Roselawn loamy sand, and the yellowish-brown subsoil is slightly darker than in Roselawn loamy sand. In most places Rubicon sand is strongly acid to a depth of 5 feet or more.

This soil has been cut over and burned over since the county was first settled. From 70 to 80 percent of it is now covered with scrub oak and brush, and the rest is pastured or farmed. Crop yields are small, unless large quantities of lime, manure, and commercial fertilizers are used, and even then lack of moisture is a limiting factor in crop production. Cherry and apple orchards planted on Rubicon sand are not successful without heavy fertilization of the soil, and even when this is done yields of fruit are usually small.

Rubicon sand, broken phase.—The broken phase of Rubicon sand is mapped largely in Benona, Golden, and Leavitt Townships. It constitutes areas of Rubicon sand which occur on plains that are broken and pitted. All the white pine timber has been removed from this land, and at present it is largely stump and grass land. It is less valuable, especially for agricultural purposes, than Rubicon sand.

Plainfield sand.—Plainfield sand occupies about one-half of Greenwood and Otto Townships and also occurs in other parts of the county. More than 90 percent of the land is covered with scrubby second-growth oaks mixed with smaller numbers of young jack pines and white pines. The original forest was apparently white pine, but, judging from the stumps, there was only a sparse stand of small or medium-sized trees.

The plow soil in a plowed field, or the topsoil in woods, of Plainfield sand is very similar to the topsoil of cultivated areas of Rubicon sand, that is, it is gray or dark-gray medium sand low in organic matter. Below the topsoil the sand is deep yellow, and this color grades into grayish yellow at a depth of about 18 or 20 inches. Most of this soil is strongly acid to a depth of more than 5 feet.

Plainfield sand occurs on the driest parts of the White River plain, whereas Rubicon sand occupies positions in which the water table is slightly nearer the surface of the ground.

The agricultural value of Plainfield sand is very low, and very little of the land is cultivated, although some areas west of Shelby apparently provide a living to several farmers who produce fruits and a few general farm subsistence crops.

The boundary between Rubicon sand and Plainfield sand is somewhat arbitrarily drawn across the southern part of the county, as differentiation between the two soils was difficult to determine in many places.

Ottawa loamy fine sand.—Practically all of Ottawa loamy fine sand is in the southwestern part of the county. It occurs on smoothly undulating plains, where the land, for the most part, is free of stones and boulders. This soil has a slightly higher moisture content than Plainfield sand, but it is too dry for high yields of most field crops. Most of the land has been under cultivation at some time.

Under cultivation the plow soil is dark-gray loose loamy fine sand. It is underlain by brownish-yellow fine sand which at a depth ranging from 30 to 36 inches grades into grayish-brown sand. At a depth ranging from 5 to 8 feet below the surface, dark reddish-brown clay is reached. In fact this soil may be briefly described as a layer of sand, ranging from 5 to 10 feet in thickness, overlying clay. The depth of the sand differs, because the surface of the underlying clay is not level. The sand is acid throughout, but the clay is alkaline.

Beans, corn, rye, potatoes, oats, and tree fruits are grown, and fair yields are obtained with the use of lime, manures, commercial fertilizers, and good management. Probably about 75 percent of this soil is cropped, and the rest is pastured.

Ottawa loamy fine sand, rolling phase.—The rolling phase of Ottawa loamy fine sand is very inextensive. It occurs in close association with typical Ottawa loamy fine sand. The soil material is essentially the same, but the relief is broken, pitted, and is characterized by numerous slopes and grades that are troublesome in the use of farm machinery. The use of this rolling soil is more limited than that of typical Ottawa loamy fine sand, and the land is largely pastured or left in wood lots.

Wallace fine sand.—Wallace fine sand occurs chiefly in the northwestern and western parts of the county, west of Mears and east and north of Pentwater, where it occupies definite ridges of sand, ranging in width from 100 to 300 feet and in height from 10 to 50 feet, in close association with soils of the Kalkaska, Saugatuck, and Newton series.

A distinguishing characteristic of this soil is the coffee-brown cemented hardpan that occurs in most places at a depth ranging from 4 to 10 inches, and in general ranges from 4 to 10 inches in thickness, although in many places it is thicker. The topsoil, or plow soil, is gray fine sand low in organic matter, and beneath the hardpan the material is light-gray nearly pure sand.

Probably 90 percent of this soil has had the topsoil removed by the wind, and the ridges contain numerous blow-outs, or depressions, from which the wind has removed much sand.

These sand ridges are of very little value for agriculture, as they are naturally low in essential plant nutrients, the underlying hardpan hinders the penetration of plant roots, and the land is very droughty.

Weare fine sand.—Weare fine sand occurs chiefly in Weare and Pentwater Townships. It consists of ridges and mounds of sand closely resembling Rubicon sand in profile, but it differs in position, relief, and character of vegetation. It occupies an intermediate stage between Bridgman fine sand and Wallace fine sand. It has no hardpan layer as does Wallace fine sand, and it contains more organic matter and has a more definite development of color than Bridgman fine sand.

The plow soil, or topsoil, is gray fine sand which is slightly loamy, owing to the content of organic matter. The subsoil is dark brownish-yellow slightly loamy sand. At a depth of 12 inches this material is underlain by loose incoherent yellow sand. In the virgin condition, a 4-inch layer of ash-gray sand occurs between the brownish-yellow sandy layer and the dark-gray virgin topsoil, but under cul-

tivation, these two layers are mixed to form gray fine sand. In most places this soil is strongly acid to a depth of more than 5 feet.

Weare fine sand has about the same agricultural value as the Roselawn, Rubicon, and Plainfield sands. About 75 percent of the land is cleared, but much of the cleared land has been abandoned. About 25 percent of the land is covered with second-growth maple, wild cherry, elm, beech, poplar, and oak trees.

Bridgman fine sand.—Bridgman fine sand occurs only along or near the coast of Lake Michigan, where it occupies a small total area. It consists of old dunes that are now stationary and either forested or covered with a shrub vegetation. The present forest cover on much of the land is largely oak, jack pine, Norway pine, and a few scattered white pine trees. On the more stable dunes directly along the lake shore, there is, or originally was, a mixture of the various hardwoods and conifers common to this section.

A ¼- to ½-inch layer of organic matter has accumulated on the surface of the nearly pure quartz sand which is very low in plant nutrients. The soil material in the cleared areas of these dunes and in many spots, even where the trees have been cut and the stumps left standing, starts to blow and is likely to revert to shifting sand dunes.

Dune sand.—The greater part of the small total area of dune sand, or shifting dunes, occurs in one body between Silver Lake and Lake Michigan, where the sand is steadily moving inland. It is reported to have moved inland as much as 35 feet on the north shore of Silver Lake in 1 year, and here it constitutes a menace to property used as resorts. All areas along the coast, where the sand is shifting and blowing, are mapped as dune sand. This sand is not utilized for commercial purposes.

IMPERFECTLY DRAINED SOILS

The imperfectly drained soils have developed under intermediate drainage conditions. They include soils that are now sufficiently well drained that they do not need artificial drainage in order to grow fruits or general crops, as well as some soils that are so poorly drained as to require some artificial drainage for most farm crops. In all soils of this group the water table is nearer the surface than in any soil previously described, and it is generally lower than in any of the poorly drained soils.

The agricultural value of these soils ranges from good to poor for general farm crops and from medium to poor for tree fruits. The best soils of the group for general crops are naturally the poorest soils for tree fruits, because the water table in such soils is too near the surface for fruit trees.

A total area of only 39.6 square miles, or 7.2 percent of the land in the county, is included in this group, but more than half of the total area of these soils is under cultivation, and they produce an important part of the agricultural products of the county.

Ogemaw sandy loam.—The total area of Ogemaw sandy loam is small. This soil occurs chiefly in association with Kent silt loam and the Isabella soils or in places where a 1- to 3-foot layer of sand overlies heavy clay. The largest area is in the southeastern corner of Greenwood Township, and many smaller bodies are scattered over

the western part of the county, particularly in Claybanks and Benona Townships. Originally, the land supported a dense stand of sugar maple, beech, hemlock, ash, elm, and basswood, with a few pines intermixed, but now more than 90 percent of it is cleared and under cultivation. The relief is smooth or undulating, and the soil is practically free of stones or boulders. Artificial drainage must be installed on some areas before the land will be suitable for most crops.

In most places the plow soil is dark-gray friable sandy loam fairly high in organic matter. At a depth of 10 or 12 inches, a 4- to 10-inch layer of dark reddish-brown or coffee-brown sand occurs, which in most places is somewhat cemented into a hardpan. In places this cemented layer is so close to the surface that it has been broken and mixed with the plow soil, and fragments of the hardpan can be seen when plowing. This reddish-brown layer in some places rests on heavy reddish-brown or mixed gray and red sandy clay, and in other places, a layer of dingy grayish-white sand occurs between the brown layer and the clay. The depth of the clay below the surface ranges from 15 to 40 inches in most places, and in some places it is greater. The sandy part of the soil ranges from medium to strongly acid, but the underlying clay contains ample lime.

Ogemaw sandy loam is farmed similarly to Kent silt loam. Under good fertility-maintaining management, the land usually produces from fair to good yields of corn, beans, oats, rye, wheat, and clover and timothy hay. Small acreages of potatoes and cucumbers are grown as cash crops, and small acreages are devoted to apple orchards, but the land is usually too wet during fall and spring for the successful growth of fruit trees.

Under normal conditions of tilth, weather, and farm practice, acre yields of corn range from 20 to 40 bushels, wheat 10 to 25 bushels, hay ½ to 2 tons, oats 30 to 45 bushels, beans 10 to 25 bushels, and rye 10 to 20 bushels. Good results are obtained from the use of both green and barnyard manures and from commercial fertilizers, and fair results from moderate applications of marl or lime.

Iosco sandy loam.—The small areas of Iosco sandy loam are chiefly in Crystal Township. The land originally was covered with a dense stand of hardwood trees similar to those on the Emmet soils. This soil closely resembles Ogemaw sandy loam but has more strongly undulating or gently rolling relief, better natural drainage, and a brighter colored subsoil and substratum than that soil.

The sandy covering over clay ranges from 18 inches to 4 feet in thickness. The better natural drainage makes artificial drainage unnecessary, and there are practically no stones or boulders. The sandy covering ranges from strongly to medium acid, and the underlying clay from neutral to alkaline.

Iosco sandy loam is slightly better adapted to fruit trees than Ogemaw sandy loam, and a few apple orchards are growing on it. It has about the same adaptation to general farm crops as Ogemaw sandy loam, but the yields obtained are slightly larger.

Arenac loamy sand.—Arenac loamy sand is not an extensive soil. Its main occurrence is in the northwestern and southwestern parts of the county. In general, it is closely associated with Kalkaska loamy sand and Rubicon sand, but in Oceana County most of it is

associated with Kalkaska loamy sand. The land originally supported a forest cover predominantly of hardwoods.

The only noticeable difference between Kalkaska loamy sand and Arenac loamy sand is that, at a depth ranging from 3 to 5 feet, mottled sand occurs, in other words, gray sand with rust-brown splotches, indicating that the water table remains at this level for considerable periods. In most places waterlogged sand is present a few inches beneath the mottled zone. In places clay holds up this water table, but, in most places in this county, clay does not occur within 6 feet of the surface.

The plow soil is dark-gray or gray loamy sand, with a medium low content of organic matter. The thickness of the dark surface soil differs, according to the length of time the land has been under cultivation and the amount of wind erosion to which it has been subjected, but in most cultivated fields it ranges from 4 to 6 inches in thickness. Beneath the plow soil is a thin layer of leached gray sand, underlying which is a 6- to 12-inch layer of dark brownish-yellow or umber-brown loamy sand, and below the brown layer is yellowish-gray sand. This soil ranges from strongly to medium acid to a depth ranging from 4 to 5 feet.

The natural fertility of this soil originally was medium high, but now the fertility ranges from medium to low. Practically all of the land has been cleared or cut over. Areas in which the water table is highest are generally the ones still in cultivation. In areas where the water table does not lie at too great a depth and crop rotation and soil-improvement methods are practiced, fair crops of beans, rye, corn, oats, potatoes, and hay are obtained. Yields are smaller than those obtained from Iosco sandy loam.

Arenac fine sandy loam.—Arenac fine sandy loam occurs in scattered small areas over the western half of the county. One of the larger bodies is in northeastern Pentwater and northwestern Weare Townships. The relief ranges from slightly undulating to nearly flat. In many places, this soil is associated with Emmet sandy loam and the Isabella soils. It does not contain boulders or stones in sufficient numbers seriously to interfere with cultivation.

The topsoil, or plow soil, of Arenac fine sandy loam is dark-gray mellow fine sandy loam fairly high in organic matter. The subsoil is reddish-brown loamy sand which grades into whitish-gray loamy sand or sand at a depth of about 18 inches. At a depth of 30 inches brownish-red mottlings occur in the gray sand, and at a depth ranging from 36 to 48 inches the material consists of reddish-gray heavy sandy clay. The sandy part of this soil ranges from strongly to medium acid, but the clay contains an abundance of lime.

This soil, where carefully managed, produces the same crops as are grown on Ogemaw sandy loam, with similar yields. It is not extensively planted to fruit trees, owing to its poor subsoil drainage and the fact that most areas do not have good air drainage.

In sections 13 and 14 of Grant Township, an area mapped as Arenac fine sandy loam more closely resembles Saugatuck sandy loam, but, as it is the only area of this type in the county, it is included with Arenac fine sandy loam. It is fully as productive as typical Arenac fine sandy loam.

Otto fine sandy loam.—Otto fine sandy loam occurs chiefly in sections 2 and 3 of Otto Township. About 75 percent of the land is cleared and utilized for farm crops.

The topsoil, or plow soil, is gray or light-gray very fine sandy loam which is medium high in organic matter and is strongly acid. Below the topsoil is whitish-gray fine sand and silt that becomes dingy gray with rust-brown mottlings, at a depth of 16 or 18 inches. In some places a layer of dark reddish-brown sand and silt is just below the topsoil. At a depth of 36 inches, layers of intermixed gray and rust-brown fine sand alternate with layers of pinkish-brown silty clay. This soil is strongly acid to a depth exceeding 3 feet.

An area included with Otto fine sandy loam in northern Weare Township is somewhat better drained than most of the soil. It required some artificial drainage, but was a comparatively easy soil to drain. Its relief ranges from undulating to nearly flat. The topsoil in this included area is gray or light-gray fine sandy loam. The subsoil, between depths of 8 and 14 inches, is very light gray very fine sandy loam. At a depth ranging from 14 to 24 inches below the surface, the material consists of alternate layers of reddish-brown very fine sand and clay and grayish-brown fine sand and clay. This material is somewhat cemented when dry and slightly sticky when wet. Below this clayey material the substratum is gray sand with a brown cast.

Fair crops of timothy hay, rye, corn, beans, and potatoes are obtained on Otto fine sandy loam, and yields are slightly lower than the average for the county. This soil requires artificial drainage and needs good soil-improvement practices, in order to obtain the best yields of which it is capable.

Saugatuck sand.—Saugatuck sand is not extensive in this county. One of the larger areas is in western Grant Township, two fair-sized bodies are in northeastern Hart Township, and smaller areas are scattered somewhat generally over the county. This soil occupies level plains. It is intermediate in elevation and drainage between the Arenac soils and the Newton soils. In the cut-over condition, it is especially characterized by a ground cover of wintergreen and bracken, with poplar as the predominating tree growth. Under natural conditions the water table ranges from 18 to 24 inches below the surface during most of the year.

This soil is characterized by a coffee-brown sand layer, at a depth ranging from 10 to 18 inches below the surface, that in many places is indurated into a hardpan. Under cultivation, the plow soil is gray or very light gray sand mixed with reddish-brown sand in places where the brown layer occurs near enough the surface to be reached by the plow. Under natural conditions the organic-matter content of this soil is low, and it is depleted rapidly under cultivation unless much organic material is returned to the soil to replace that removed. In many places there is a layer of white sand between the plow soil and the coffee-brown layer. Beneath the brown layer is the substratum of gray sand which, in general, shows signs of being water-soaked during most of the year. Saugatuck sand is strongly acid to a depth exceeding 4 feet.

Perhaps 50 percent of this soil is or has been cultivated, especially that in Grant, Otto, Ferry, and Weare Townships, where fair crops of corn, potatoes, rye, strawberries, oats, and hay are produced under good soil management, and in places where the fertility has not become too much depleted.

The soil originally supported a cover of white pine and swamp hardwoods, but now the uncleared areas support second-growth poplar and a ground cover of bracken and wintergreen.

Eastport sand.—Practically all of the small total area of Eastport sand lies along the shore of Lake Michigan. It includes beach ridges and mounds of sand as well as flat areas of recently deposited sand. Organic matter has accumulated on the surface where the sand is stable; but elsewhere the sand is uniformly gray throughout. Beachgrass and a few shrubs, such as juniper, willow, and poplar, are characteristic of the sparse vegetation on this sand. The land has little or no value for agriculture.

POORLY DRAINED SOILS

The poorly drained soils, or those that in their native condition had the water table at or near the surface during most of the year, cover 102.1 square miles, or 19 percent of the total area of the county. Not more than 25 percent of their total area is cultivated, and the rest is in pasture or is waste land. All these soils occur in nearly level or depressed areas and, owing to their low position and lack of air drainage, are especially subject to frost. None of them contains sufficient stones or boulders to interfere with cultivation. All require some type of artificial drainage, and many occur in positions where it is impractical to attempt to drain them. None of them is suitable for growing fruit trees. This group may be subdivided into two subgroups—poorly drained mineral soils and poorly drained organic soils.

MINERAL SOILS

Perhaps 50 percent of the total area of the poorly drained mineral soils is cultivated, and the rest is either pastured or supports a cover of second-growth brush and trees. These soils are included in the Bergland, Munuscong, Granby, Newton, Maumee, Griffin, Washtenaw, Wallkill, and Warners series.

Bergland loam.—Bergland loam occurs in small areas widely scattered over all parts of the county. It is the poorly drained associate of Isabella loam, and it originally supported a dense stand of swamp white oak, black ash, elm, basswood, red maple, aspen, hemlock, and a few white pine trees.

In cultivated areas, the topsoil, or plow soil, is very dark gray friable granular loam high in organic matter. The topsoil ranges from slightly acid to neutral. Below this layer the material is gray, reddish-brown, and yellow sandy clay, the colors being mixed and streaked, with the gray predominating. This layer contains an abundance of lime.

Included with Bergland loam as mapped are areas in Claybanks Township, which occur chiefly as low wet spots in association with Kent silt loam. In such areas the plow soil is very dark gray clay loam with a coarse granular structure. Between depths of 6 and 14

inches the material is deep reddish-brown clay with leached gray sandy loam filling the seams and cracks that cause coarse blocks from 1 inch to 3 inches in diameter to form in the clay. The material in this layer grades into mixed pinkish-brown, rust-brown, and gray clay that contains an abundance of lime. The topsoil ranges from slightly acid to neutral and the subsoil from neutral to alkaline.

Corn, hay, and oats are the main crops grown on Bergland loam. The greater part of it is used for timothy hay and bluegrass pasture. Beans, rye, and wheat are grown to less extent. Good yields are obtained when the soil is sufficiently drained and the frost-free season is sufficiently long. Crops not readily injured by frost and wet ground, such as hay and oats, are more certain to produce good yields on this soil. Strawberries are successfully grown.

Munuscong sandy loam.—Munuscong sandy loam occurs in small areas in places throughout the county, where a 2- to 3-foot layer of wet sand overlies heavy clay. It occupies gentle slopes at the bases of steep hills and also occurs on valley floors. The relief is gently undulating.

The topsoil consists of very dark gray fine sandy loam which, in most places, ranges from neutral to slightly acid in reaction. The subsoil is dingy-gray sandy loam, generally neutral in reaction, which extends to a depth ranging from 20 to 40 inches, where it is underlain by gray and red heavy sandy clay that contains an abundance of lime.

Most of the land has been cleared and placed under cultivation. It is more generally under cultivation than Bergland loam, as it is easier to work and drain. Average-sized yields of potatoes, corn, hay, beans, rye, and oats are obtained. Much of Munuscong sandy loam occupies a higher position and is therefore less subject to frost than Bergland loam.

Granby fine sandy loam.—Some of the larger areas of Granby fine sandy loam are in Grant, Newfield, and Leavitt Townships. In general, this soil occupies lower positions and flatter relief than Munuscong sandy loam, and the topsoil is finer, smoother in texture, and ranges from neutral to alkaline in reaction. Below the topsoil, waterlogged whitish-gray fine sand, with a few thin layers of silt, extends to a depth of 5 feet or more before clay is reached. The subsoil is alkaline in reaction.

About 50 percent of Granby fine sandy loam has been cleared, drained, and placed under cultivation. This is a popular strawberry soil in some sections of the county. Average yields of corn, oats, rye, beans, and hay are obtained from moderately well managed fields of Granby fine sandy loam.

Newton loamy sand.—Newton loamy sand occurs in both small and medium-sized areas. Its position and relief are very similar to those features of Granby fine sandy loam.

Newton loamy sand differs from Granby fine sandy loam, however, in that it has an acid topsoil which is slightly lighter colored and is lighter textured. The subsoil differs, in that this layer of Newton loamy sand is strongly acid to a depth of more than 5 feet.

About 20 percent of the land has been cleared and drained, and it is now under cultivation. The principal crops are corn, oats, beans, hay, and strawberries, and a few special crops are grown. Yields are usually slightly lower than the average for the county.

Newton sandy loam.—The total extent of Newton sandy loam is small. This soil occurs in small areas in the eastern part of the county. In most places it contains less fine sand than does Granby fine sandy loam. Otherwise the main difference between the two soils is that the Newton soil is strongly acid to a depth of 4 feet or more instead of being alkaline as is the Granby soil. Newton sandy loam is utilized chiefly for pasture and hay land.

Maumee loam.—Maumee loam is not extensive. The largest areas are in Leavitt, Newfield, and Ferry Townships. This land is very nearly flat, as it occurs on low-lying plains.

The topsoil of Maumee loam consists of a mixture of black mucky organic matter and sand forming a very dark gray loam which in general is acid in reaction. Below this is light-gray sand similar to that beneath the topsoil of Granby fine sandy loam. In most places this sand is neutral in reaction.

Corn, hay, oats, barley, and rye are the principal crops grown. Probably 50 percent of the land is cropped, and the rest is either pastured or is in wood lots.

Griffin sandy loam.—Griffin sandy loam occurs chiefly along the larger streams. It is a poorly drained soil of the first bottoms of streams that overflow during periods of high water.

The 6- to 8-inch topsoil consists of dark-gray sandy loam. The underlying material is variable, ranging from recently deposited brownish-yellow sand to dark-gray sandy loam, mottled with rust brown. The latter material is the most common.

The land is used mainly as pasture, and the tree growth is used for wood, lumber, and posts. Elm, ash, silver maple, red maple, white cedar, and other swamp species of trees and brush grow in these bottoms.

Griffin silty clay loam.—Griffin silty clay loam occurs chiefly along Flower Creek in Claybanks Township, and one small area is along South Branch White River in Greenwood Township. This soil is similar to Griffin sandy loam, except that the topsoil of the silty clay loam is heavy dark-gray silty clay loam with a coarse crumb structure. The underlying material is slightly lighter gray. It has the same heavy texture and contains some rust-brown mottlings at a depth ranging from 6 to 10 inches below the surface. The dark heavy alluvium extends to a depth of several feet.

Some of the land has been cleared, but, as drainage is so uncertain, this soil is used chiefly for hay and pasture land. The natural fertility of the soil is very high.

Washtenaw sandy loam.—Washtenaw sandy loam occurs in small areas throughout the county. It occupies small elongated depressions or valleys where the amount of wash is considerable and the soil is kept wet by seepage from the hills during most of the year. In places small intermittent streams flow through areas of this soil.

Washtenaw sandy loam differs from Griffin sandy loam, in that the deposited material is recent, probably most of it having been laid down since the land was cleared, and comes from the adjoining slopes.

The texture of the surface soil ranges from loam to light sandy loam, but in most places it is very dark gray sandy loam, fairly high in organic matter and very fertile, which extends to a depth ranging from 15 to 20 inches. In reaction it ranges from slightly acid to

neutral. The material beneath the dark surface soil ranges from sandy loam and clay mixtures to sand and sandy loam materials of various shades of gray, rust brown, and yellow. The variation in the soil material is largely determined by the character of the surrounding soils.

Some of the broader and longer bodies, that are not too wet, are cropped to oats, corn, rye, beans, potatoes, and hay, and during seasons when the rainfall is not too heavy and frosts do not occur too early, good yields are obtained from these crops. The land is more generally used for hay and pasture.

Wallkill loam.—Wallkill loam is a very inextensive soil occurring in small scattered areas over the county. It occupies small depressions, or pot holes, where an original muck or organic deposit has had recent mineral material superimposed on it or mixed throughout the topmost 6- to 16-inch layer. These areas are subject to early and late frosts, and most of them are difficult to drain, so they are used chiefly for hay or pasture land. Perhaps half of Wallkill loam occurs as brush-covered unused swampy spots within cultivated fields.

Warners loam.—Warners loam is an inextensive soil. Marl underlies many areas in the county. Those mapped as Warners loam have only a 6- or 8-inch layer of organic matter or dark mineral soil above the marl, whereas other areas have from 1 to 3 feet or more of muck over the marl. A few of the marl deposits underlying Warners loam are dry enough that the marl may be shoveled directly into wagons or trucks, without any trouble from water. Such deposits occur around Stony Lake, and in sections 24 and 36 of Grant Township. Other areas of Warners loam, such as those around McLaren Lake, have a high water table, and the marl cannot be so easily handled as that in the dry deposits. The "dry-land marl" is widely used for agricultural purposes, and utilization of the wetter material is increasing each year.

ORGANIC SOILS

The poorly drained organic soils are classified as Kerston, Carlisle, and Houghton mucks, burned muck over clay, burned muck over sand, and Rifle and Greenwood peats.

Kerston muck.—Kerston muck occurs along the larger streams, chiefly along South Branch White River and Pentwater River. It is subject to flooding, as are the Griffin soils, but it is composed of mixed deposits of muck or peat and mineral alluvium, forming a soil that contains a higher proportion of organic material than of mineral material. Along the edges of the bottoms the material in many places is nearly pure muck or organic matter, but near the stream channel it is a mixture of mineral and organic material. In some places layers of mineral soil, high in organic matter, and muck alternate, and in other places the soil consists of a more or less composite mixture of organic and mineral materials.

Some of Kerston muck is pastured, but some of the land is too wet and low to be of much value as pasture land. The original cover ranges from grasses to dense stands of white cedar, elm, ash, swamp white oak, red maple, silver maple, and other swamp vegetation.

Carlisle muck.—Carlisle muck is the most extensive organic soil in the county. Large bodies of it are in Ferry, Elbridge, and Leavitt Townships. It is the predominating soil in the last-named township. The deposits of this muck range in thickness from 18 inches to 30 feet, and some may be thicker.

Carlisle muck is composed almost entirely of decayed and partly decayed or decomposed organic matter. The 6- to 12-inch surface layer is very dark brown or black granular well-decomposed organic matter, with little or no content of mineral material. This layer, in most places, is sufficiently decomposed that no plant remains can be distinguished, although pieces of wood lie on top of the muck and are easily pushed into it. The underlying material is less well decomposed and, to a depth of about 3 feet, seems to be a mixture of well-decomposed and partly decomposed material predominantly of woody origin. Where the deposits are more than 3 feet thick, the underlying material in most places seems to be partly decomposed grasses, sedges, reeds, and rushes.

Most of this land is pastured or is left uncleared for the production of wood and posts, but in Leavitt Township fairly large areas are planted to barley, corn, and hay crops. From fair to good yields of corn and hay are obtained, and barley of the Spartan variety has been reported to yield as high as 65 bushels an acre. In other parts of the county, Carlisle muck is but slightly used for crops, as crops grown on muck are especially susceptible to injury by late spring or early fall frosts.

In some places Carlisle muck seems to be saturated with water from springs or spring-fed streams, thereby making the land colder, more difficult to drain, and less valuable for cultivated crops. To some extent this condition is expressed by the natural vegetation. If the natural vegetation is predominantly white cedar, it seems safe to say that the muck is cold, that the water comes from springs or cold streams, and that the possibility of making this muck a good general- or special-crop soil, especially for the crops commonly grown in Oceana County, is small. On the other hand, muck areas supporting red maple, silver maple, ash, elm, swamp oak, hemlock, and similar trees do not seem to be so cold, and consequently are better for general or special crops.

Houghton muck.—The larger bodies of the small total area of Houghton muck are at the head of Pentwater Lake and along North Branch White River. This type of muck differs from Carlisle muck, in that it is developed from grasses, sedges, reeds, rushes, and other water-loving vegetation, rather than from woody material. It commonly occurs in old lake or pond beds that have grown over or become filled with organic matter and have not yet been invaded by trees. It supports marsh grasses, cattails, rushes, and sedges, some of which are cut for hay. The areas not used for hay land are pastured.

Rifle peat.—Rifle peat is brown or dark-brown coarse woody or loamy peat, high in organic matter (75 percent or more). The material is underlain, at a depth ranging from 6 to 24 inches, by a fibrous or coarser textured type of organic matter which shows very little decomposition. In most places the depth to the water table ranges from 1 to 2 feet, and the peat may have an alkaline or slightly

acid reaction. The vegetation is characterized by a dense growth of arborvitae, spruce, balsam fir, and tamarack, with an occasional hemlock and white pine. Where the forest growth has been cut over and burned, dense thickets of aspen, alder, willow, and white birch have grown up, and the treeless open places are covered with a heavy cover of sedge (*Carex filiformis*) and bluejoint grass. The land has little or no agricultural value, but from some places the sedges and grass are cut for hay.

Greenwood peat.—Greenwood peat occurs in scattered areas over the county, the largest body being in Colfax Township. This type of peat consists of brown stringy poorly decomposed very strongly acid peat, which in most places supports a dense matted growth of shrubs, predominantly leatherleaf. Cranberries and huckleberries can tolerate the strong acidity of this material, but they do not commonly grow on Greenwood peat in Oceana County. This peat should not be used as a top dressing on mineral soils, and at present it has no agricultural use.

Burned muck over clay.—Dry muck or peat is inflammable, and in some areas this material has been burned. Where areas showing definite evidence that peat or muck has been burned off to a depth of 1 or more feet, and a clay substratum exposed, the material is designated as burned muck over clay. There is comparatively little burned muck in this county. The value of some muck areas is increased by burning, but in places where all the muck material has been burned down to the underlying mineral material, the value of burning is questionable, although the resultant mineral soil is probably slightly less subject to damage from frost than the original muck.

Burned muck over sand.—Burned muck over sand is similar to burned muck over clay, in that it consists of ashes and the remains of organic deposits which have been destroyed by fire. It differs in that it overlies sand or, where cultivated, is mixed with sand. Such areas, where drained, have essentially the same agricultural value and possibilities for use as Granby fine sandy loam.

SOILS AND THEIR INTERPRETATION

Oceana County lies within a belt between the Podzol soil region to the north and the Gray-Brown Podzolic soil region to the south. Representatives of both of these great soil groups occur in the county, in addition to a small total area of dark-colored grassland, or Prairie, soils. The soils of the county fall into three major soil groups, as indicated in the following outline:

1. Well-drained soils:
    - A. Podzol soils:
        - *a.* Soils developed under coniferous or pine forest.
            - (1) Sandy loams, loams, and silt loams.
            - (2) Sands and loamy sands.
        - *b.* Soils developed under deciduous or hardwood cover.
            - (1) Sandy loams.
            - (2) Sands and loamy sands.
    - B. Gray-Brown Podzolic soils:
        - *a.* Soils developed under coniferous forest.
            - (1) Sandy loams.
            - (2) Sands and loamy sands.
        - *b.* Soils developed under deciduous or hardwood cover.
    - C. Prairie soils.

2. Imperfectly drained soils:
   a. Soils developed under coniferous vegetation.
   b. Soils developed under deciduous vegetation.
   c. Soils developed under mixed vegetation.
3. Poorly drained soils:
   a. Mineral soils.
   b. Organic soils.

The organic-matter content of the well-drained fully developed soils is low except in the Prairie soils. Under virgin forest, the organic matter of the Podzol soils is fairly definitely separated from the mineral soil. The topmost ½- to 1-inch layer of mineral soil is, in most places, stained dark gray or brown by organic matter. The accumulation of organic matter ranges in thickness from one-half inch to 1½ inches under the pine forest and from 1 to 3 inches beneath the hardwoods. In the Podzol soils this accumulation is only moderately well decomposed and is matted together by numerous fine roots. In the Gray-Brown Podzolic soils more completely decomposed organic matter is mixed with the 2- or 3-inch surface layer of mineral matter, and from one-half to 1 inch of less well-decomposed organic material lies on top of the mineral soil.

The dark-colored well-drained Prairie soils are relatively high in organic matter, which is well decomposed and incorporated with the mineral soil. The total area of these soils is small, and they probably can be classed as anomalies, or at least as not conforming to their environment.

The poorly drained soils have a moderately high content of organic matter. In the sandy poorly drained soils the black mucky organic matter is partly decomposed and distinctly separated from the mineral soil, whereas in the heavier textured poorly drained soils the organic matter is more completely decomposed and sightly mixed with the upper part of the mineral soil, although decomposition of the organic matter is not so complete as in similar soils from 50 to 100 miles farther south.

At the time this county was settled it was entirely covered by forest, with the exception of the beaches, the lake and pond areas that had recently grown over, and some small prairie areas in the southeastern part. At present no virgin stands or even near-virgin stands of pine forest remain on the well-drained soils, but there are areas of uncleared stump land. The stumps are sufficiently numerous to indicate that only underbrush and a very few trees of other species could have grown in association with the pine. In other locations, where the pine stumps are more widely separated, it is possible that the forest was more intermixed with other species of trees, possibly oak, beech, maple, and hemlock. Several virgin or very near virgin remnants of the hardwood forest that originally covered an important part of the well-drained land still remain, wherein the predominating trees are sugar maple, beech, and hemlock. A few white pine trees grow in places, and, in most places, ash, basswood, ironwood, and elm are mixed through the forest.

According to the small amount of evidence available, the imperfectly drained soils evidently supported the same general type of forest as grew on the well-drained soils, but it seems probable that the species were considerably more intermixed on the imperfectly drained soils. Coniferous forests undoubtedly predominated on some of the

poorly drained soils, but there is no evidence as to what species were present other than white and red pines. The deciduous forests on the poorly drained soils consisted of black ash, white ash, red maple, silver maple, elm, hemlock, and yellow birch as the predominant trees, intermixed with a few white pines and other species.

The following five different types of vegetation grow on the organic soils: (1) Predominantly white cedar with a few white pine, elm, ash, and swamp oak trees; (2) black ash, white ash, red maple, and other trees, practically the same as the deciduous forest on the poorly drained mineral soils; (3) predominantly tamarack, mixed with poplar, pine, spruce, and cedar, and a ground cover of ferns and mosses; (4) almost entirely leatherleaf and moss, with a few scattered huckleberry bushes, tamarack, and clusters of bushes that tolerate a highly acid soil environment; and (5) a cover consisting of mixtures of marsh grasses, sedges, rushes, cattails, and reeds, without any one predominating.

The parent materials of the mineral soils of this county consist of glacial drift, in part ice-laid and in part water-laid. There is marked variation in both chemical and physical composition of the drift, which in turn influences the character of the soils. The more distinctive kinds of drift are described in the following paragraphs:

(1) Till clay which is heavy, compact, and massive pale reddish-brown sandy clay or clay. This material is calcareous, contains few stones or boulders, and has only a small content of gravel. It occurs in scattered areas and forms the parent material of about 15 percent of the soils of the county.

(2) Light sandy drift with a high carbonate content, which consists of yellowish-gray medium sand high in quartz, with numerous stones and boulders, especially limestone, scattered throughout.

(3) Material similar to the light sandy drift, but having thin layers and lenses of reddish-brown sandy calcareous clay mixed throughout the sandy drift. In some places pockets of calcareous sand and gravel also occur in this type of drift.

(4) Light sandy glacial drift low in carbonates. It consists of gray medium sand high in quartz, with comparatively few stones and boulders mixed with it.

(5) Very closely associated with the no. 4 type of material is similar glacial drift consisting of lenses and layers of brownish-red and pinkish-brown sandy clay, together with fine sand and silt, which in places is calcareous. Some pockets of calcareous sand and gravel are scattered through this material. Limestone or dolomite are noticeably absent in these last two types of parent material.

(6) The parent material of the outwash plains is more or less assorted gray medium sand from the glacial drift of the county, containing a few pockets and beds of calcareous sand and gravel in isolated spots; but most of the outwash-plain material has a high content of quartz and is low in carbonates. About 35 percent of the total soil area of the county developed from this type of parent material.

In general, the soils developed from calcareous parent material supported a hardwood cover, whereas the soils developed from drift low in carbonates supported a coniferous, or pine, cover.

On the outwash plains two distinct types of well-drained soils developed presumably from the same parent material—one with a hardwood cover and the other with a pine cover.

The deposits of organic matter in the deeper poorly drained depressions constitute a distinct kind of parent material. The bottom materials are derived from sedges, grasses, and herbaceous and aquatic plants. Overlying most of this material is a layer of material derived from woody vegetation which grew during a later cycle. Organic soils comprise 9.7 percent of the total area of the county.

A definite Podzol soil profile has developed in practically 50 percent of the land, and fairly typical Gray-Brown Podzolic soils have developed in about 15 percent of the total land area. The lighter textured members of the group of Gray-Brown Podzolic soils show evidence, in virgin areas, of being incipient Podzols. This development is so faint that its evidence has been largely destroyed by lumbering operations as well as by plowing in places where the soil is under cultivation. The heaviest textured well-drained soil, Kent silt loam, definitely belongs to the group of Gray-Brown Podzolic soils. It occurs in large and medium-sized bodies over the entire county. On the northern county line it is still typical, in all characteristics, of a Gray-Brown Podzolic soil. Only a small area of Podzol soils adjoins Muskegon County on the south, and only a small total area of Gray-Brown Podzolic soils—in fact, no light-textured member of that group—lies north of the center of Oceana County.

The well-drained soils extend over the entire county, and the profile of Emmet loamy sand, as observed under virgin conditions in Hart Township, in the NW¼NW¼ sec. 32, may be considered representative of the Podzol sand soils developed under a hardwood cover. The relief of this area ranges from gently rolling to rolling. A description of this profile follows:

A_0. Dark-brown forest litter composed of disintegrated leaves, woody material, and other organic matter matted together by roots, with sand mixed into it to some extent in the lower portion. This mat is strongly acid and 2 inches thick.

A_1. 0 to 1 inch, a mixture of organic matter and grayish-brown strongly acid sand.

A_2. 1 to 9 inches, lavender-gray medium sand which is very slightly laminated in place and is strongly acid.

B_1. 9 to 20 inches, dark yellowish-brown or umber-brown medium sand or loamy sand, consisting of sand with a small but conspicuous content of colloidal organic matter, which accounts for the coloration. The material is strongly acid.

B_2. 20 to 72 inches, brownish-yellow medium sand which is medium acid.

C. 72 inches +, gray medium sand, dominantly quartz, but with a small content of silicate minerals and in places grains of limestone. The material in this layer ranges from neutral to alkaline.

Limestone boulders and gravel, together with a great variety of other rocks, are scattered throughout the profile.

The virgin forest consisted of sugar maple, beech, and hemlock as the predominant trees, with a smaller number of elm, basswood, ironwood, hickory, and wild cherry. There was a small amount of underbrush.

Emmet sandy loam is similar to Emmet loamy sand in general profile characteristics, but it contains throughout a higher proportion of silt and clay, and the B horizon consists of red sandy clay which is

neutral or slightly alkaline. This layer is underlain by pinkish-brown sandy loam with clay and silt particles in the layers and lenses. The material in the underlying sandy loam and clay layer is slightly plastic when wet and is alkaline or calcareous in reaction. Limestone boulders and gravel are generally more numerous than in Emmet loamy sand. The forest cover, which is dense, consists of the same species as those growing on Emmet loamy sand.

Kalkaska loamy sand developed on outwash plains under a forest cover similar to that growing on the Emmet soils. Its profile is essentially the same as that of Emmet loamy sand. The parent material of assorted medium sand has developed into a uniformly textured soil, free of stones and boulders. The lavender-gray leached layer and the umber-brown layer are more uniform in thickness than the corresponding layers in Emmet sandy loam or Emmet loamy sand.

The Podzol soils developing under a coniferous forest cover are distinctly different in several respects from the Podzol soils developed under hardwoods. Only about one-half as much organic matter has accumulated on the "pine soils" as on the "hardwood soils." The leached layer is of about the same thickness in both types of profiles, but the brown, or orterde, layer is thinner and much lighter colored in the pine soils, in many places being more yellow than brown.

Roselawn loamy sand is a good example of a soil developed under a pine cover, with gently sloping or rolling relief. The parent material contains a comparatively small amount of carbonates. Following is the description of a profile of Roselawn loamy sand as observed in Colfax Township in the NE¼NE¼ sec. 9, T. 16 N., R. 15 W. The soil in this place was unplowed, but the original tree growth has been entirely removed and replaced by second-growth trees.

A_0. A thin layer of acid organic litter composed chiefly of pine needles.
A_1. 0 to 1 inch, dark-gray loamy sand consisting chiefly of quartz sand mixed with finely divided organic matter. The material is strongly acid.
A_2. 1 to 4 inches, very light gray strongly acid sand composing the leached layer.
B. 4 to 12 inches, yellowish-brown loamy sand stained by colloidal organic matter. The material is not cemented and is strongly acid.
C. 12 to 48 inches, grayish-yellow strongly acid medium sand.

The abundance of stumps remaining on cut-over land indicates that white pine originally was the predominant species in the forest. The present forest cover consists of poplar, pin cherry, scrub oaks, witch-hazel, a few scrub maple, sassafras, bracken, wild raspberries (both black and red), and much sweetfern.

That Montcalm sandy loam developed from a parent material differing from that of Roselawn loamy sand is apparent from the fact that it has a more reddish coloration. The profile is similar in essential characteristics. The relief ranges from mildly sloping to gently rolling. The original vegetation was mainly white pine, as evidenced by the numerous large stumps, maple, beech, and hemlock, together with oaks and, probably, other hardwood species. The second growth includes sassafras, poplar, and scrubby oaks, with a few white pine, pin cherry, maple, and beech.

Coventry silt loam is a soil closely associated with Roselawn loamy sand. Following is the description of a profile of this soil as observed in Colfax Township in the NW¼NE¼ sec. 15, in an unplowed area under second-growth forest:

A_0 and A_1. A 2-inch cover of very dark grayish-brown organic matter containing a few particles of sand and clay mixed throughout, overlying dark partly decomposed acid organic matter, slightly matted with fine roots.
A_2. 0 to 3 inches, ash-gray smooth loam or very fine sandy loam, which is strongly acid. This layer is not everywhere distinct.
B_1. 3 to 15 inches, brownish-yellow silty loam or fine sandy loam, which is strongly acid. In some places it extends to a depth of 24 inches.
B_2. 15 to 30 inches, reddish-brown light sandy clay or clayey sand, which is strongly acid.
C. 30 inches +, reddish-brown loose incoherent strongly acid sand.

The original vegetation on this soil was predominantly white pine which evidently grew large and in thick stands. The present second growth consists of sassafras, poplar, red oak, wild cherry, black oak, and witch-hazel.

Rubicon sand is the outwash-plain soil developed under a pine cover. It differs from Roselawn loamy sand in relief, topographic position, and its freedom from stones and boulders.

Kent silt loam may be regarded as representative of the Gray-Brown Podzolic soils. It is developed on heavy calcareous glacial till clay, under a dense hardwood forest. The relief is undulating or gently sloping. Following is the description of a profile of this soil as observed under virgin conditions near the center of sec. 35, T. 13 N., R. 18 W. (Claybanks Township):

1. A thin layer of forest litter consisting chiefly of debris from deciduous hardwoods.
2. 0 to 2 inches, very dark gray or dark-gray strongly acid silt loam with a soft crumb structure. The organic-matter content is high, well decomposed, and incorporated with the mineral soil.
3. 2 to 10 inches, light yellowish-brown heavy silt loam or silty clay loam, which is strongly acid.
4. 10 to 20 inches, dark yellowish-red heavy clay or silty clay, which is plastic when wet and when dry breaks into angular blocks ranging from one-half to three-fourths inch in diameter. The material in this layer is slightly acid.
5. 20 inches +, yellowish-red calcareous till clay which breaks into small angular blocks when dry.

The natural vegetation on this soil consists of sugar maple, beech, hemlock, basswood, elm, and ash, the first three named predominating.

Isabella loam is similar to Kent silt loam, except that its slightly lighter textured parent material has weathered to a depth ranging from 12 to 20 inches greater. The Isabella soil is lighter textured throughout and has a higher content of sand.

Bridgman fine sand, or the forest-covered dunes along Lake Michigan, has the least development of a profile among the soils of this county. It is well drained and occurs as ridges, hills, and mounds with both steeply and gradually sloping sides. The original forest on the old stable dunes directly along the lake shore contained a mixture of practically all the trees and shrubs common to this section. A ¼- to ½-inch layer of partly decomposed dark-brown organic matter is covered by a layer of fairly recent litter. Below the organic matter is a very thin layer of gray fine sand, 3 or 4 inches thick in most places, which occurs only in undisturbed areas. Below this the material consists of a 6- to 10-inch layer of light brownish-yellow fine sand which grades into the pale-yellow or grayish-white sand composing the unweathered part of the dunes.

Sparta loamy sand occurs in small bodies on the sandy outwash plain in the southern part of the county. It is surrounded by areas of

Plainfield sand. It ranges from somewhat flat to undulating in relief and perhaps lies from 3 to 6 feet lower than some of the surrounding Plainfield sand areas. The parent material is the same as that of Plainfield sand and Rubicon sand. The vegetation consists of wild native grasses other than bluegrass, mosses, and a few bur oak and wild-cherry trees. These prairie areas are small and closely surrounded by scrub oak, wild cherry, and a few small white pine trees. Following is the description of a profile of Sparta loamy sand as observed in the SW¼SE¼ sec. 36, Otto Township:

0 to 12 inches, very dark brownish-gray or nearly black loamy sand which is acid in reaction and high in well-decomposed organic matter well mixed with the sand.
12 to 24 inches, brown strongly acid medium sand.
24 to 36 inches, gray strongly acid medium sand.

The imperfectly drained soils are not extensive. In general, they occupy topographic positions where the water table has not yet been sufficiently lowered to afford good drainage. However, some of them have heavy clay substrata that retard internal drainage. As a group these soils have Podzol profiles, and a few have ortstein, or hardpan layers of concentration. Such soils are included with the ground-water Podzols.

Arenac loamy sand presents an example of a profile influenced in its development by a high water table. It occupies an undulating plain and has developed from parent material similar to that underlying Rubicon sand and Kalkaska loamy sand. The vegetation consists of a hardwood forest similar to that on the Emmet and Kalkaska soils. Following is the description of a profile of Arenac loamy sand as observed in the NW¼NW¼ sec. 14, R. 18, W., T. 13 N. (Claybanks Township):

1. A thin layer of acid forest litter.
2. 0 to 2 inches, very dark gray sand composed of medium sand and partly decomposed organic matter, penetrated by fine roots. The material in this layer is strongly acid.
3. 2 to 8 inches, lavender-gray strongly acid fine sand.
4. 8 to 16 inches, brown or yellowish-brown strongly acid slightly loamy medium sand.
5. 16 to 36 inches, pale-yellow strongly acid medium sand.
6. 36 to 40 inches, brownish-yellow strongly acid medium sand mottled with rust brown or reddish brown.
7. 40 to 44 inches, gray sand containing bright-yellow mottlings.
8. 44 inches +, gray wet acid sand. Probably some clay occurs in many places between depths of 50 and 60 inches.

Saugatuck sand differs from Arenac loamy sand, in that its water table is higher and the brown layer in most places is somewhat indurated. The leached layer of Saugatuck sand ranges from 6 to 12 inches in thickness, and water-soaked whitish-gray sand lies directly below the brown, or indurated, layer. The profile is strongly acid throughout. Pine was the predominant original tree. The present forest cover consists of poplar, birch, and swamp oaks, with a ground cover of wintergreen, bracken, shrubs, and vines.

Iosco sandy loam is imperfectly drained because of the heavy underlying clay. The relief is undulating or mildly sloping. Practically all of this soil has been cleared, but indications are that it was covered with a hardwood forest similar to that originally on Kalkaska loamy sand and Arenac loamy sand. Following is a description of

a profile of this soil as observed in the NW¼NE¼ sec. 18, Crystal Township:

1. A thin layer of forest litter.
2. 0 to 3 inches, a mixture of very dark grayish-brown partly decomposed organic matter and gray sandy loam. The material in this layer is strongly acid.
3. 3 to 8 inches, light-gray or lavender-gray strongly acid loamy sand.
4. 8 to 18 inches, reddish-brown sandy loam, a layer of concentration of organic colloids. The material is strongly acid and slightly indurated.
5. 18 to 30 inches, light-gray sandy loam containing reddish-brown mottlings.
6. 30 inches +, brownish-red heavy sandy clay which is plastic when wet and when dry crumbles into irregular lumps from one-half to three-fourths inch in diameter. The material is calcareous.

The poorly drained soils have developed with the water table at or near the surface of the ground most of the time. Considerable leaching has taken place, but there is no noticeable development of a layer of maximum concentration.

The organic matter on most of the poorly drained soils resembles that of the Podzol soil regions. The heavier textured, poorly drained soils have accumulated considerable organic matter which has become mixed with the mineral soil, and they still contain carbonates in the upper layers of the mineral soil.

Newton loamy sand has developed from a parent material of sand that probably was originally low in carbonates. This soil is closely associated with Saugatuck sand and might be considered the same soil, with the water table at the surface and the ortstein layer missing, or whitish-gray waterlogged sand from the dark surface soil downward. The sand is strongly acid to a depth of several feet.

The soils of this group developing from clay parent material have a dark-colored layer high in organic matter, underlain by a layer of gray material which is slightly lighter in texture than the parent material. Below the gray layer, the heavy plastic clay grades rather abruptly into the parent material at a depth ranging from 10 to 16 inches.

There is only a small total area of soils developed from alluvium, all of which are poorly drained. All the deposited material is of local origin, and much of it has been recently deposited, so that little or no development of a profile has taken place. The mineral alluvium is mapped as Griffin soils, and the mixed mineral and muck, or organic soil, alluvium is mapped as Kerston muck.

The organic soils—mucks and peats—are deposits of nearly pure organic matter. The deposits range from 2 feet to more than 20 feet in thickness but average about 8 feet. The deposits that are more than 2 feet thick probably originally were lakes that filled with the remains of marsh and water vegetation and afterward were invaded by a forest vegetation. In such places, the topmost 2 feet of material consists mainly of remains of woody vegetation. Carlisle muck and Rifle peat were both apparently developed in this way. Carlisle muck is the older deposit of the two, and the material in the upper part of its profile is more completely decomposed and has a more granular structure. The forest cover of Rifle peat is predominantly tamarack, whereas Carlisle muck has developed to the point where it supports a forest cover of elm, ash, soft maple, swamp oak, and white cedar. Houghton muck is derived entirely from reeds,

sedges, rushes, marsh grasses, and a water-plant vegetation, and it is still covered with that type of vegetation. Greenwood peat is raw, poorly decomposed, highly acid material derived from marsh vegetation and acid-tolerant shrubs. In this county it is covered almost entirely by leatherleaf.

CLASSIFICATION OF SOIL TYPES ACCORDING TO PRODUCTIVITY

Table 6 gives a classification of the soil types, according to productivity, for each of the important crops grown in Oceana County.

TABLE 6.—*Classification of soil types in Oceana County, Mich., according t*

Soil type	Productivity rating according to—		Crop productivity index								
	Inherent productivity [2]	Current practices [3]	Corn (grain)	Corn (silage)	Wheat	Oats	Rye	Tamegrass hay [4]	Red clover	Alfalfa	Fiel bea
	Grade no.	*Grade no.*									
Isabella loam	1	1	50(70)	60(80)	60(80)	70(90)	70	70(100)	70(90)	40(70)	70(
Kent silt loam	2	2	50(70)	60(80)	60(80)	70(90)	70	70(100)	80(100)	50(80)	70(
Isabella sandy loam			50(70)	60(80)	50(70)	60(80)	70	60(80)	60(80)	30(70)	70(
Emmet sandy loam, smooth phase	3	2	50(70)	60(80)	50(70)	50(80)	70	60(80)	50(80)	30(60)	60(
Antrim sandy loam			50(70)	50(70)	40(60)	50(70)	60	60(80)	50(70)	30(60)	50(
Emmet sandy loam		3	40(60)	50(70)	40(60)	40(60)	50	50(70)	40(70)	30(60)	50(
Coventry silt loam	4	4	40(60)	50(70)	40(60)	40(70)	50	50(70)	40(60)	10(50)	40(
Ottawa fine sandy loam		4	40(60)	50(70)	40(60)	50(70)	50	40(60)	40(60)	20(50)	40(
Echo loamy sand		4	40(60)	40(60)	40(60)	50(70)	50	40(60)	30(60)	30(50)	50
Arenac fine sandy loam	5	5	40(60)	40(60)	40(60)	50(70)	50	50(70)	40(70)	10(40)	40(
Iosco sandy loam		4	30(50)	40(60)	40(60)	40(60)	60	30(50)	40(70)	20(40)	40(
Montcalm sandy loam		4	40(50)	40(50)	40(60)	40(60)	50	40(60)	30(60)	10(50)	30(
Ogemaw sandy loam, drained	5	4								20(40)	50(
Ogemaw sandy loam, undrained	6	5	40(60)	50(70)	40(60)	50(70)	50	40(60)	[9] 50(80)	10	20
Emmet loamy sand, smooth phase	6	4	30(50)	30(50)	30(50)	40(70)	50	40(50)	30(60)	20(50)	30(
Bergland loam, drained	2	3	60	80	50(70)	60(80)	50	100	90	30(40)	60(
Bergland loam, undrained	9	9					10	30	[9] 40		
Oshtemo sandy loam	6	5	40(50)	40(50)	30(50)	40(50)	50	30(50)	30(60)	10(40)	30(
Ottawa loamy fine sand			30(50)	30(50)	30(50)	40(60)	50	30(50)	20(40)	20(40)	30(
Munuscong sandy loam, drained	3	4	50(70)	60(80)	40	60(80)	60	80	80	30(40)	60(
Munuscong sandy loam, undrained	9	9				30	10	30	[9] 20		
Kalkaska loamy sand	6	5	30(50)	30(50)	30(50)	40(60)	40	30(40)	20(50)	10(40)	30(
Burned muck over clay, drained	3	4	60	70	60	90	70	80	70	60	
Burned muck over clay, undrained	10	10						10	10		
Granby fine sandy loam, drained	4	5	50	50	40	50	50	60	70	30(40)	50(
Granby fine sandy loam, undrained	9	9						40	[9] 20		
Maumee loam, drained	4	5	50	60	40	50	40	60	70	30(50)	50(
Maumee loam, undrained	10	10						20	[9] 20		
Griffin silty clay loam, drained [10]	4	5	60	70	50	70	50	80	[9] 80		30
Griffin silty clay loam, undrained [11]	10	10						20	[9] 20		
Arenac loamy sand	7	6	20(40)	20(40)	30(50)	30	40	20(40)	20(50)	10	30(
Washtenaw sandy loam, drained	5	6	60	60	40	50	50	60	60		30
Washtenaw sandy loam, undrained	9	10				20		30	20		

Footnotes at end of table.

TABLE 6.—*Classification of soil types in Oceana County, Mich., according to prod*

Soil type	Productivity rating according to—		Crop productivity index								
	Inherent productivity [3]	Current practices [3]	Corn (grain)	Corn (silage)	Wheat	Oats	Rye	Tame-grass hay [4]	Red clover	Alfalfa	Fie bea
	Grade no.	*Grade no.*									
Emmet loamy sand	7	6	20(40)	20(40)	20(40)	30(50)	40	30(40)	20(50)	10(40)	20(
Burned muck over sand—drained	4	5	50	50	40	70	60	60	50	50	----
Burned muck over sand—undrained	10	10						10	10		
Griffin sandy loam—drained [10]	4	5	50	50	60	60	60	70	[9] 60		40
Griffin sandy loam—undrained [11]	10	10						10	[9] 20		
Otto fine sandy loam—drained	6	6	40	40	30	40(50)	40	50	40	10(30)	20(
Otto fine sandy loam—undrained	9	9	20	20		20	10	20	[9] 20		
Roselawn loamy sand, smooth phase	8	8	20	30	20	30	40	20	10(30)	10(20)	10(
Sparta loamy sand			20	30	20	30	40	20	10	10	
Newton sandy loam—drained	6	6	40	50	20	40	30	50	30(50)		20(
Newton sandy loam—undrained	10	10						20	10		
Newton loamy sand—drained	7	7	30	40	20	30	30	40	30		20(
Newton loamy sand—undrained	10	10						20			
Roselawn loamy sand	8	9	10	20	10	20	30	10	10(20)	10(20)	10(
Carlisle muck—drained	7	5	40(60)	50(80)	10(30)	30(50)	20(40)	30(70)	20(60)		
Carlisle muck—undrained	10	10						10			
Saugatuck sand—drained	7	7	30	30	10(30)	40(50)	30	40	20(50)		20
Saugatuck sand—undrained	10	10									
Rifle peat—drained	8	6	30	50	10(40)	20(40)	30	20(60)	20		
Rifle peat—undrained	10	10						10			
Plainfield sand	9	9	10	10	10	10	30	10	10(20)	10(20)	10
Rubicon sand			10	10	10	10	30	10			10
Weare fine sand			10	10	10	10	30	10			10
Houghton muck—drained	8	9		20	10	10	10	20	40		
Houghton muck—undrained	10	10						10	20		
Ottawa loamy fine sand, rolling phase	9	9					20	20	10	10	
Warners loam—drained	9	9						30	50		
Warners loam—undrained	10	10						10	10		

Wallace fine sand	10	10					20	10				
Kalkaska loamy sand, broken phase								10	10			
Bridgman fine sand							10	10				
Eastport sand							10	10				
Wallkill loam												
Kerston muck												
Rubicon sand, broken phase												
Greenwood peat, drained												
Greenwood peat, undrained												
Dune sand												

[1] Soil types inherently most productive in the United States for the specified crop=100. Only those inherently most produc the standard. Unusually productive soils of limited acreage rate above 100. Figures in parentheses indicate the productivity acc soil amendments, as lime, fertilizers, and manure.

[2] Soil types having the highest general inherent productivity in the county are rated grade 1. When 2 inherent productivity r number when the land is drained, or protected from flood, and the lower figure refers to the grade number when the land is und

[3] This grade number gives the comparative productivity according to the current farm practices of management on the variou

[4] In the case of items such as tame-grass hay, vegetables, small fruits, melons, and tree fruits, which include a group of associate soil type for that member of the group best adapted to the soil type in question. Thus, soil types well adapted to apples may be ex their adaptability to peaches or other fruits may be poor. In Oceana County, timothy, cherries, and raspberries were the principa fruits, and small fruits, respectively. Because of the importance of alsike clover as a hay and of apples and strawberries as tree fr were used as criteria for rating certain soil types. (See footnotes 8, 9, and 10.)

[5] Vegetables doing best on highly organic soils; e. g., onions, celery, lettuce.

[6] Vegetables not requiring highly organic soils.

[7] These indexes refer to apples as the best adapted tree fruit to the soil type.

[8] These indexes refer to strawberries as the best adapted small fruit to the soil type.

[9] These indexes refer to alsike clover instead of red clover.

[10] Land with optimum protection from overflow.

[11] Land with no protection from overflow.

NOTE.—Blank spaces, according to position, indicate either that the crop is not grown because of extremely poor adaptation

This classification compares the inherent productivity of each of the soil types in the county for a given crop, to a standard, namely, 100, which is given to the soil type (or types) of significant acreage in the United States that is inherently most productive for that crop. This index is called the base index and is the standard with which the productivity of all other soil types for that crop is compared. Therefore, a soil type estimated to be about half as productive for that crop as the best in the United States receives an index of 50. In a few instances unusually productive soils of limited acreage will carry, necessarily, an index above 100 for a specified crop. The inherent productivity indexes are based on the ability of the land to produce under a management capable of maintaining the inherent or natural level of productivity.

In addition to productivity indexes for each important crop, each soil type is assigned a general productivity rating, or grading, of agricultural quality. The soil types having the highest average productivity indexes in the county are given the rating, or grade, of 1 for that county, the soil types having the next highest the grade of 2, and so on. The soil types falling in the same grade are listed in table 6 in the order of highest average inherent productivity indexes.

In the determination of this general productivity grade, more weight is given to productivity of the important staple crops than of minor crops. These values indicate, as nearly as possible, the inherent or natural productive capacity of the soil types, regardless of such important considerations as differences due to previous management and the accessibility of markets.

Obviously the inherent or natural productive capacity of land means the productivity without the repeated use of amendments. Yields obtained through the use of amendments, as lime, water, and fertilizer do not indicate well the inherent productivity. Some soil types, however, although low in inherent productivity, are responsive to the application of amendments and produce good yields or high quality of product. Because the index of inherent productivity does not express the responsiveness of soil types to fertilizer, a second index is used (in parentheses) to compare the productive capacity of a given soil type under the amendment practices where it occurs with the inherently most productive soil type in the United States for that crop. Thus the same standard of reference is used as for the inherent crop-productivity index. This second index (in parentheses) compares what may be expected in the way of yield and quality of product from different soil types under current practices of culture. Quality of product average being equal, it would be approximately the same as a comparison of average yield of product. This index is used only where amendments are added to the land as a common practice.

A second general productivity rating is assigned in column 3 to the soil types to indicate their relative productivity in the county under current practices of management. This rating is determined in the same general manner as the productivity rating for inherent productivity. In the case of those soil types which are not amended under practices of current management, the inherent productivity rating is the basis of the productivity rating according to current practices.

The physical factors influencing the productivity of land are mainly those of climate, soil, and surface configuration. All are considered in the determination of the productivity indexes, and a low index for a particular crop may as likely be due to an unfavorable climate or surface configuration as to fertility of soil. Surface configuration is important mainly on account of its influence on the amount of water which penetrates the soil and, with some soils, on erosion. It is, of course, also a secondary factor that helps to determine the character of both climate and soil.

In the case of soil types with poor natural drainage, two series of indexes are given, one applying to the soil types with no artificial drainage, the other to soil types to which optimum artificial drainage has been applied. In many instances some artificial drainage but not the optimum has been applied to poorly drained lands so that their inherent productivity under optimum drainage is not realized.

In the case of bottom land subject to periodic overflow, two sets of indexes are given, one applying to the land when it receives optimum protection from overflow, the other to the land with no such protection. This double series of indexes is used to indicate the potential inherent productivity in addition to the present inherent productivity of poorly drained or overflow land.

The cost or difficulty of effecting drainage or protection from overflow plays no part in the potential inherent productivity rating of such lands. Two kinds of soil having the same productivity when drained are rated the same, although optimum artificial drainage may cost 10 times as much on one as on the other.

It must be stated clearly that this classification is not to be interpreted directly into specific land values. The intention is to confine attention to essentially permanent factors of inherent productivity and not to include transitory economic considerations. In some instances the information on which the ratings are based is not so complete as desired; in these cases further study may suggest changes.

In the following tabulation are some of the numerical yields per acre which have been set up for standards of 100. When applied to the inherently most productive soil types of significant acreage, they represent long-time production averages without the use of soil amendments to alter the inherent productivity of the soil type for a product of satisfactory quality.

Corn (grain)	bushels	50
Wheat	do	25
Oats	do	50
Rye	do	25
Timothy	pounds	4,000
Red clover	do	4,000
Alfalfa	do	9,000
Field beans	bushels	25
Potatoes	do	200

U. S. GOVERNMENT PRINTING OFFICE: 1937

Authority for printing soil survey reports in this form is carried in the Appropriation Act for the Department of Agriculture for the fiscal year ending June 30, 1933 (47 U. S. Stat., p. 612), as follows:

There shall be printed, as soon as the manuscript can be prepared with the necessary maps and illustrations to accompany it, a report on each soil area surveyed by the Bureau of Chemistry and Soils, Department of Agriculture, in the form of advance sheets bound in paper covers, of which not more than two hundred and fifty copies shall be for the use of each Senator from the State and not more than one thousand copies for the use of each Representative for the congressional district or districts in which a survey is made, the actual number to be determined on inquiry by the Secretary of Agriculture made to the aforesaid Senators and Representatives, and as many copies for the use of the Department of Agriculture as in the judgment of the Secretary of Agriculture are deemed necessary.

Areas surveyed in Michigan shown by shading. Detailed surveys shown by northeast-southwest hatching; reeconnaissance surveys shown by northwest-southeast hatching.

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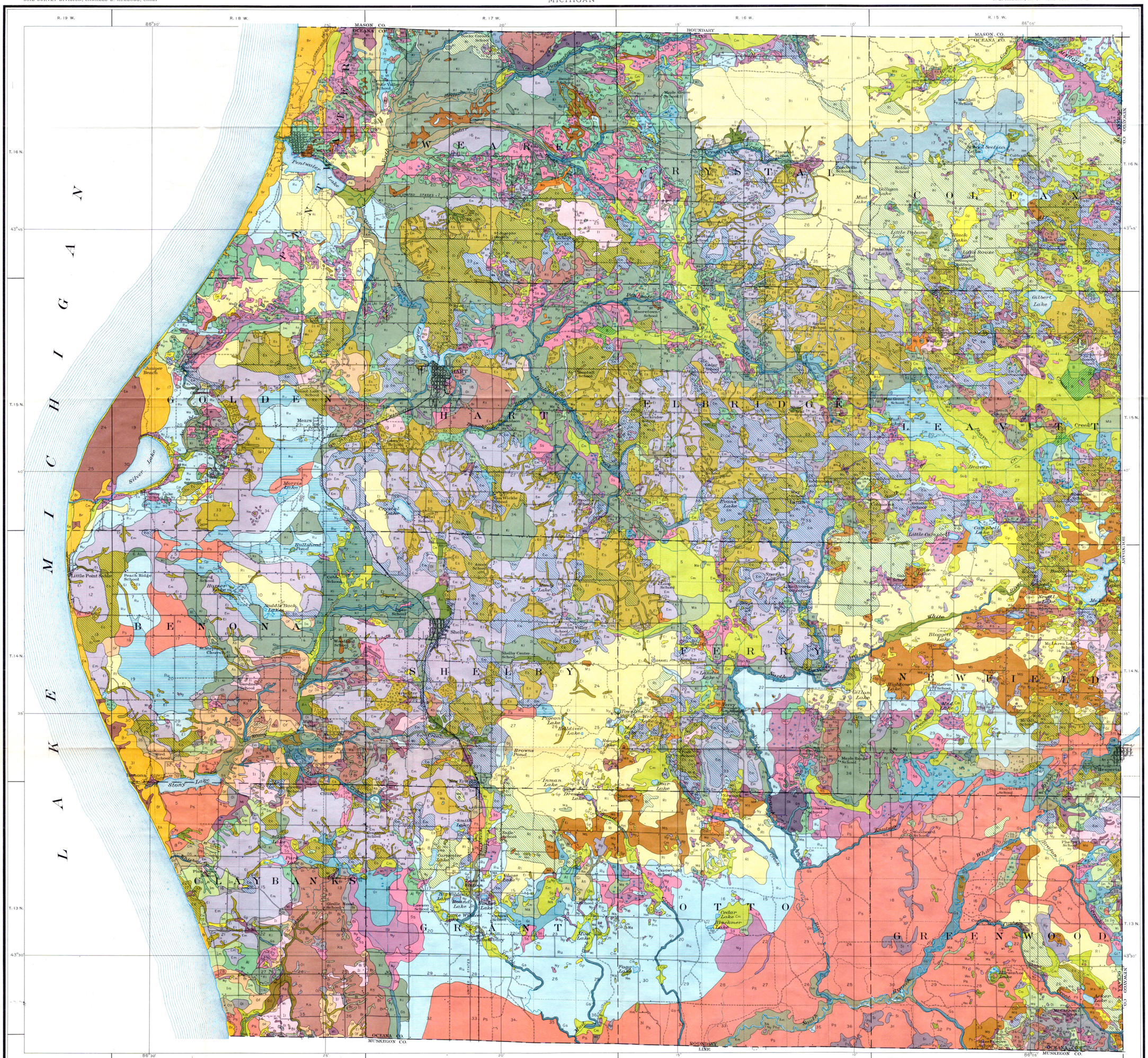
BUREAU OF CHEMISTRY AND SOILS
HENRY G. KNIGHT, CHIEF
SOIL SURVEY DIVISION, CHARLES E. KELLOGG, CHIEF

SOIL MAP

OCEANA COUNTY
MICHIGAN

MICHIGAN AGRICULTURAL EXPERIMENT STATION
V. R. GARDNER, DIRECTOR
C. E. MILLAR, IN CHARGE SOIL SURVEY



LEGEND

Antrim sandy loam (An)	Griffin sandy loam (Gs)	Ogemaw sandy loam (Ol)	Wallace fine sand (Wa)
Arenac loamy sand (Al)	Griffin silty clay loam (Gc)	Oshtemo sandy loam (Os)	Wallkill loam (Wk)
Arenac fine sandy loam (As)	Iosco sandy loam (Is)	Ottawa loamy fine sand (Of); Of Rolling phase	Warners loam (Wl)
Bergland loam (Bl)	Isabella sandy loam (Im)		Washtenaw sandy loam (Ws)
Bridgman fine sand (Br)	Isabella loam (Il)	Ottawa fine sandy loam (Od)	Weare fine sand (Wf)
Coventry silt loam (Cs)	Kalkaska loamy sand (Kl); Kl Broken phase	Otto fine sandy loam (Ot)	Greenwood peat (Gp)
Eastport sand (Ea)		Plainfield sand (Ps)	Rifle peat (Rp)
Echo loamy sand (El)	Kent silt loam (Ks)	Roselawn loamy sand (Rl)	Carlisle muck (Cm)
Emmet loamy sand (Em); Em Smooth phase	Maumee loam (Ma)	Rl Smooth phase	Houghton muck (Hm)
	Montcalm sandy loam (Ms)	Rubicon sand (Ru)	Kerston muck (Km)
Emmet sandy loam (Es); Es Smooth phase	Munuscong sandy loam (Ml)	Ru Broken phase	Burned muck (B) Over clay
	Newton loamy sand (Ny)	Saugatuck sand (Ss)	B Over sand
Granby fine sandy loam (Gl)	Newton sandy loam (Ns)	Sparta loamy sand (Sl)	Dune sand (D)

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort.
Secondary roads and Trails
Railroads Steam and Electric
Bridges, Ferry
R.R. crossings, Tunnel
Ford, Dam
School or Church Cemeteries
Mine or Quarry Mine dumps Made land
Bluff, Escarpment, Rock outcrop and Triangulation station
Stony and Gravelly areas
Soil boundaries
Boundary lines
Boundary lines
Boundary lines
U. S. township and section lines

RELIEF
(Printed in brown or black)

Contours Depression contours
Prominent Hills Mountain Peaks
Sand, Wash, and Sand dunes
Shore and Low-water line, Sandbar

DRAINAGE
(Printed in blue)

Streams
Lakes, Ponds, Intermittent lakes
Intermittent streams
Springs, Canals and Ditches, Flumes
Swamp Salt marshes
Submerged marsh Tidal flats

The above signs are in current use on the soil maps. Variations from this range appear in some maps of earlier dates.

Mark Baldwin, Inspector, District 1.
Soils surveyed by C. H. Wonser, U. S. Department of Agriculture, in charge, and J. O. Veatch and L. R. Jones, Michigan Agricultural Experiment Station.

BASE MAP IN PART FROM U. S. GEOLOGICAL SURVEY SHEETS.

Scale 1 inch-1 mile
1 ½ 0 1 2 3 4 Miles

LITHO EASTERN OFFSET INC., BALTO.

Field Operations
Bureau of Chemistry and Soils
1933